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International Baccalaureate Organization

Diploma Programme

Sports, exercise and health science

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The Diploma Programme

The Diploma Programme is a rigorous pre-university course of study designed for students in the 16 to 19 age range. It is a broad-based two-year course that aims to encourage students to be knowledgeable and inquiring, but also caring and compassionate. There is a strong emphasis on encouraging students to develop intercultural understanding, open-mindedness, and the attitudes necessary for them to respect and evaluate a range of points of view.

The Diploma Programme hexagon

The course is presented as six academic areas enclosing a central core. It encourages the concurrent study of a broad range of academic areas. Students study: two modern languages (or a modern language and a classical language); a humanities or social science subject; an experimental science; mathematics; one of the creative arts. It is this comprehensive range of subjects that makes the Diploma Programme a demanding course of study designed to prepare students effectively for university entrance. In each of the academic areas students have flexibility in making their choices, which means they can choose subjects that particularly interest them and that they may wish to study further at university.

Choosing the right combination

Students are required to choose one subject from each of the six academic areas, although they can choose a second subject from groups 1 to 5 instead of a group 6 subject. Normally, three subjects (and not more than four) are taken at higher level (HL), and the others are taken at standard level (SL). The IBO recommends 240 teaching hours for HL subjects and 150 hours for SL. Subjects at HL are studied in greater depth and breadth than at SL.

At both levels, many skills are developed, especially those of critical thinking and analysis. At the end of the course, students' abilities are measured by means of external assessment. Many subjects contain some element of coursework assessed by teachers. The course is available for examinations in English, French and Spanish.

The core of the hexagon

All Diploma Programme students participate in the three course requirements that make up the core of the hexagon. Reflection on all these activities is a principle that lies at the heart of the thinking behind the Diploma Programme.

The theory of knowledge (TOK) course encourages students to think about the nature of knowledge, to reflect on the process of learning in all the subjects they study as part of their Diploma Programme course, and to make connections across the academic areas. The extended essay, a substantial piece of writing of up to 4,000 words, enables students to investigate a topic of special interest that they have chosen themselves. It also encourages them to develop the skills of independent research that will be expected at university. Creativity, action, service (CAS) involves students in experiential learning through a range of artistic, sporting, physical and service activities.

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The IBO mission statement and the IB learner profile

The Diploma Programme aims to develop in students the knowledge, skills and attitudes they will need to fulfill the aims of the IBO, as expressed in the organization's mission statement and the learner profile. Teaching and learning in the Diploma Programme represent the reality in daily practice of the organization's educational philosophy.

Nature of the subject

The attainment of excellence in sport is the result of innate ability or skill and the dedicated pursuit of a programme of physical and mental training accompanied by appropriate nutrition. Training programme design should not be left to chance. Rather, it should be designed thoughtfully and analytically after careful consideration of the physiological, biomechanical and psychological demands of the activity. This is the role of the sport and exercise scientist, who, regardless of the athletic event, should be equipped with the necessary knowledge to be able to perform this task competently. Furthermore, in a world where many millions of people are physically inactive and afflicted by chronic disease and ill health, the sport and exercise scientist should be equally proficient when prescribing exercise for the promotion of health and wellness.

Scientific inquiry conducted over many decades, has accumulated a vast amount of information across a range of sub-disciplines that contribute to our understanding of health and human performance in relation to sport and exercise. The Diploma Programme course in sports, exercise and health science involves the study of the science that underpins physical performance and provides the opportunity to apply these principles.

The course incorporates the traditional disciplines of anatomy and physiology, biomechanics, psychology and nutrition, which are studied in the context of sport, exercise and health. Students will cover a range of core and option topics and carry out practical (experimental) investigations in both laboratory and field settings. This will provide an opportunity to acquire the knowledge and understanding necessary to apply scientific principles and critically analyse human performance. Where relevant, the course will address issues of internationalism and ethics by considering sport, exercise and health relative to the individual and in a global context.

Group 4 subjects and prior learning

Past experience shows that students will be able to study a group 4 science subject at SL successfully with no background in, or previous knowledge of, science. Their approach to study, characterized by the specific IB learner profile attributes—inquirers, thinkers and communicators—will be significant here.

Group 4 subjects and the MYP

Students who have undertaken the MYP sciences, technology and mathematics courses will be well prepared for group 4 subjects. The MYP science objectives and assessment criteria A–F are aligned with the group 4 objectives and IA criteria, and allow for a smooth transition from the MYP to Diploma Programme. In particular, the “One world” objective in MYP sciences is further developed in group 4 science with the increased emphasis on aim 8—that is, to “raise awareness of the moral, ethical, social, economic and environmental implications of using science and technology”. There are specific references to

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aim 8 implications in assessment statements and teacher's notes in the syllabus details sections in all group 4 guides.

Group 4 subjects and TOK

In looking at the ways of knowing described in the *Theory of knowledge guide* (March 2006), scientists could legitimately claim that science encompasses all these. Driven by emotion, using sense perception, enhanced by technology and combined with reason, it communicates through language, principally the universal language of mathematics.

There is no one scientific method, in the strict Popperian sense, of gaining knowledge, of finding explanations for the behaviour of the natural world. Science works through a variety of approaches to produce these explanations, but they all rely on data from observations and experiments and have a common underpinning rigour, whether using inductive or deductive reasoning. The explanation may be in the form of a theory, sometimes requiring a model that contains elements not directly observable. Producing these theories often requires an imaginative, creative leap. Where such a predictive theoretical model is not possible, the explanation may consist of identifying a correlation between a factor and an outcome. This correlation may then give rise to a causal mechanism that can be experimentally tested, leading to an improved explanation. All these explanations require an understanding of the limitations of data, and the extent and limitations of our knowledge. Science requires freedom of thought and open-mindedness, and an essential part of the process of science is the way the international scientific community subjects the findings of scientists to intense critical scrutiny through the repetition of experiments and the peer review of results in scientific journals and at conferences. The syllabus details sections in the group 4 guides give references in teacher's notes to appropriate topics where these aspects of the scientific way of knowing can be addressed.

Group 4 subjects and the international dimension

Science itself is an international endeavour—the exchange of information and ideas across national boundaries has been essential to the progress of science. This exchange is not a new phenomenon but it has accelerated in recent times with the development of information and communication technologies. Indeed, the idea that science is a Western invention is a myth—many of the foundations of modern-day science were laid many centuries before by Arabic, Indian and Chinese civilizations, among others. Teachers are encouraged to emphasize this contribution in their teaching of various topics, perhaps through the use of time-line web sites. The scientific method in its widest sense, with its emphasis on peer review, open-mindedness and freedom of thought, transcends political, religious and national boundaries. Where appropriate within certain topics, the syllabus details sections in the group 4 guides contain assessment statements and teacher's notes illustrating the international aspects of science.

On an organizational level, many international bodies now exist to promote science. United Nations bodies such as UNESCO, UNEP and WMO, where science plays a prominent part, are well known, but in addition there are hundreds of international bodies representing every branch of science. The facilities for large-scale experimental science in, for example, particle physics and the Human Genome Project, are expensive and only joint ventures involving funding from many countries allow this to take place. The data from such research is shared by scientists worldwide. Group 4 students are encouraged to access the extensive web sites of these international scientific organizations to enhance their appreciation of the international dimension.

Increasingly, however, there is a recognition that many scientific problems, from climate change to AIDS, are international in nature and this has led to a global approach to research in many areas. The reports of the intergovernmental panel on climate change are a prime example of this. Some topics in the group 4 guides are specifically written to bring out this global research.

On a practical level, the group 4 project (which all science students must undertake) mirrors the work of real scientists by encouraging collaboration between schools across the regions.

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The power of scientific knowledge to transform societies is unparalleled. It has the potential to produce great universal benefits or to reinforce inequalities and cause harm to people and the environment. In line with the IBO mission statement, group 4 students need to be aware of the moral responsibility of scientists to ensure that scientific knowledge and data are available to all countries on an equitable basis and that they have the scientific capacity to use this for developing sustainable societies.

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Aims

Through studying any of the group 4 subjects, students should become aware of how scientists work and communicate with each other. While the “scientific method” may take on a wide variety of forms, it is the emphasis on a practical approach through experimental work that distinguishes the group 4 subjects from other disciplines and characterizes each of the subjects within group 4.

It is in this context that all the Diploma Programme experimental science courses should aim to:

1. provide opportunities for scientific study and creativity within a global context that will stimulate and challenge students
2. provide a body of knowledge, methods and techniques that characterize science and technology
3. enable students to apply and use a body of knowledge, methods and techniques that characterize science and technology
4. develop an ability to analyse, evaluate and synthesize scientific information
5. engender an awareness of the need for, and the value of, effective collaboration and communication during scientific activities
6. develop experimental and investigative scientific skills
7. develop and apply the students' information and communication technology skills in the study of science
8. raise awareness of the moral, ethical, social, economic and environmental implications of using science and technology
9. develop an appreciation of the possibilities and limitations associated with science and scientists
10. encourage an understanding of the relationships between scientific disciplines and the overarching nature of the scientific method.

Assessment objectives

The objectives for all group 4 subjects reflect those parts of the aims that will be assessed. Wherever appropriate, the assessment will draw upon environmental and technological contexts and identify the social, moral and economic effects of science.

It is the intention of all the Diploma Programme experimental science courses that students achieve the following objectives.

1. Demonstrate an understanding of:
 - a. scientific facts and concepts

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- b. scientific methods and techniques
 - c. scientific terminology
 - d. methods of presenting scientific information.
2. Apply and use:
- e. scientific facts and concepts
 - f. scientific methods and techniques
 - g. scientific terminology to communicate effectively
 - h. appropriate methods to present scientific information.
3. Construct, analyse and evaluate:
- i. hypotheses, research questions and predictions
 - j. scientific methods and techniques
 - k. scientific explanations.
4. Demonstrate the personal skills of cooperation, perseverance and responsibility appropriate for effective scientific investigation and problem solving.
5. Demonstrate the manipulative skills necessary to carry out scientific investigations with precision and safety.

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Format of the syllabus content

Note: The order in which the syllabus content is presented is not intended to represent the order in which it should be taught.

The format of the syllabus content section of the group 4 guides is the same for each subject. The structure is as follows.

Topics or options

Topics are numbered and options are indicated by a letter (for example, "Topic 4: Movement analysis", or "Option C: Physical activity and health").

Sub-topics

Sub-topics are numbered and the estimated teaching time required to cover the material is indicated (for example, "3.3 Nutrition and energy systems (7 hours)"). These times are for guidance only and do not include time for practical/investigative work.

Assessment statements (AS)

Assessment statements, which are numbered, are expressed in terms of the outcomes that are expected of students at the end of the course (for example, "2.2.5 Outline the relationship between the pulmonary and systemic circulation"). These are intended to prescribe to examiners what can be assessed by means of the written examinations. Each one is classified as objective 1, 2 or 3 (see the "Objectives" section) according to the command terms used (see the "Command terms" section). The objective levels are relevant for the examinations and for balance within the syllabus, while the command terms indicate the depth of treatment required for a given assessment statement. It is important that students are made aware of the meanings of the command terms because these will be used in examination questions. (When the command term "define" is used, the word(s) or phrase to be defined is in *italics*. When the command term "distinguish" is used, the terms or concepts to be distinguished are also in *italics*.)

Teacher's notes

Teacher's notes, which are included alongside some assessment statements, provide further guidance to teachers.

They may also suggest ideas for the promotion of aim 7, aim 8, TOK and the international dimension (Int).

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Curriculum model

A common curriculum model applies to all the Diploma Programme group 4 subjects: biology, chemistry, physics, design technology and sports, exercise and health science. (There are some differences in this model for sports, exercise and health science which is offered only at SL and design technology arising from the design project, which is a unique feature of this subject.) Students of SL sports, exercise and health science study a core syllabus supplemented by the study of two options. Students at SL are required to spend 40 hours, on practical/investigative work. This includes 10 hours for the group 4 project.

SL group 4 curriculum model

SL	Total teaching hours	150
Theory		110
Core	80	
Options	30	
Practical work		40
Investigations	30	
Group 4 project	10	

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Syllabus Outline

Core [80h]		Teaching hours
Topic 1	Anatomy	[7]
	1.1 The skeletal system	4
	1.2 The muscular system	3
Topic 2	Exercise physiology	[17]
	2.1 Structure and function of the ventilatory system	5
	2.2 Structure and function of the cardiovascular system	12
Topic 3	Energy systems	[13]
	3.1 Nutrition	4
	3.2 Carbohydrate and fat metabolism	2
	3.3 Nutrition and energy systems	7
Topic 4	Movement analysis	[15]
	4.1 Neuromuscular function	4
	4.2 Joint and movement type	3
	4.3 Fundamentals of biomechanics	8
Topic 5	Skill in sport	[15]
	5.1 The characteristics and classification of skill	4
	5.2 Information processing	6
	5.3 Principles of skill learning	5

Topic 6	Measurement and evaluation of human performance	[13]
6.1	Statistical analysis	2
6.2	Study design	4
6.3	Components of fitness	4
6.4	Principles of training programme design	3

Options—standard level

Teaching hours

Option A	Optimizing physiological performance	[15]
A.1	Training	5
A.2	Environmental factors and physical performance	6
A.3	Non-nutritional ergogenic aids	4
Option B	Psychology of sport	[15]
B.1	Individual differences	5
B.2	Motivation	3
B.3	Mental preparation for sport	4
B.4	Psychological skills training	3
Option C	Physical activity and health	[15]
C.1	Hypokinetic disease	1.5
C.2	Cardiovascular disease	3
C.3	Physical activity and obesity	2
C.4	Physical activity and type 2 diabetes	2
C.5	Physical activity and bone health	2.5
C.6	Prescription of exercise for health	1.5
C.7	Exercise and psychological well-being	2.5
Option D	Nutrition for sport, exercise and health	[15]
D.1	Digestion and absorption	3
D.2	Water and electrolyte balance	4
D.3	Energy balance and body composition	2

Syllabus content—Core

Topic 1: Anatomy (7 hours)

1.1 The skeletal system

4 hours

Assessment statement	Obj	Teacher's notes
1.1.1 Distinguish anatomically between the axial and appendicular skeleton.	2	<p>Axial skeleton: limit to the skull, ribs, sternum and vertebral column consisting of cervical—7 bones, thoracic—12 bones, lumbar—5 bones, sacral—5 bones (fused as 1) and coccyx—4 bones (fused as 1).</p> <p>Appendicular skeleton: limit to the pectoral girdle (scapulae and clavicles), humerus, radius, ulna, carpals, metacarpals, phalanges, pelvic girdle (ilium, ischium and pubis), femur, patella, tibia, fibula, tarsals, metatarsals and phalanges.</p>
1.1.2 Distinguish between the axial and appendicular skeleton in terms of function.	2	Consider the anatomical functions attachment, protection, movement and support.
1.1.3 State the four types of bone.	1	Limit to long, short, flat and irregular.
1.1.4 Draw and annotate the structure of a long bone.	2	Limit to diaphysis (compact bone), epiphysis (spongy bone), articular cartilage, bone marrow (marrow cavity), blood vessel and periosteum.
1.1.5 Apply anatomical terminology to the location of bones.	2	Limit to inferior, superior, proximal, distal, medial, lateral, posterior and anterior. Limit to the bones listed in the axial and appendicular skeleton (see 1.1.1). Assume anatomical position.
1.1.6 Outline the function of connective tissue.	2	Limit to cartilage, ligament and tendon.
1.1.7 Define the term <i>joint</i> .	1	A joint occurs where two or more bones articulate.
1.1.8 Distinguish between the different types of joint in relation to movement permitted.	2	Limit to fibrous, cartilaginous and synovial joints.
1.1.9 Outline the features of a synovial joint.	2	Limit to articular cartilage, synovial membrane, synovial fluid, bursae, meniscus , ligaments and articular capsule.
1.1.10 List the different types of synovial joints.	2	Consider hinge, ball and socket, condyloid, pivot, gliding and saddle.

I.2 The muscular system

3 hours

Assessment statement	Obj	Teacher's notes
1.2.1 Outline the general characteristics common to muscle tissue.	2	Limit to contractility, extensibility, elasticity, atrophy, hypertrophy, controlled by nerve stimuli and fed by capillaries.
1.2.2 Distinguish between the different types of muscle.	2	Include smooth, cardiac and skeletal.
1.2.3 Annotate the structure of skeletal muscle.	1	Limit to epimysium, perimysium, endomysium, muscle fibre, myofibril, sarcomere, actin and myosin.
1.2.4 Define the terms <i>origin</i> and <i>insertion</i> of muscles.	1	<p>Origin-is the attachment of a muscle tendon to a stationary bone.</p> <p>Insertion- is the attachment of a muscle tendon to a moveable bone.</p>
1.2.5 Identify the location of skeletal muscles in various regions of the body.	2	<p>Include the muscles from:</p> <p>the anterior—deltoid, pectoralis, iliopsoas, sartorius, quadriceps femoris (rectus femoris, vastus intermedius, vastus medialis, vastus lateralis), tibialis anterior, abdominus rectus, external obliques and biceps brachii</p> <p>the posterior—trapezius, triceps brachii, latissimus dorsi, gluteus maximus, hamstrings (biceps femoris, semitendinosus, semimembranosus), gastrocnemius, soleus, erector spinae</p>

Topic 2: Exercise physiology (17 hours)

2.1 Structure and function of the ventilatory system

5 hours

Aim 7: There are numerous technologies used to facilitate direct measurement in respiratory research (for example, spirometer, on-line gas analysis)

Assessment statement	Obj	Teacher's notes
2.1.1 List the principal structures of the ventilatory system.	1	<p>Nose, mouth, pharynx, larynx, trachea, bronchi, bronchioles, lungs and alveoli.</p> <p>Cross reference to 1.2.2.</p>
2.1.2 Outline the functions of the conducting airways.	2	Limit to low resistance pathway for air flow, defence against chemicals and other harmful substances that are inhaled, warming and moistening the air.

2.1.3	Define the terms <i>pulmonary ventilation</i> , <i>total lung capacity</i> , <i>vital capacity</i> , <i>tidal volume</i> , <i>expiratory reserve volume</i> , <i>inspiratory reserve volume</i> and <i>residual volume</i> .	1	
2.1.4	Explain the mechanics of ventilation in the human lungs.	3	Include the actions of the diaphragm and the intercostal muscles, and the relationship between volume and pressure. Students should be aware that accessory muscles are also important during strenuous exercise.
2.1.5	Describe nervous and chemical control of ventilation during exercise.	2	<p>Limit to ventilation increases as a direct result of increases in blood acidity levels (low pH) due to increased carbon dioxide content of the blood detected by the respiratory centre. This results in an increase in the rate and depth of ventilation.</p> <p>Neural control of ventilation includes lung stretch receptors, muscle proprioceptors and chemoreceptors.</p> <p>The role of H⁺ ions and reference to partial pressure of oxygen are not required.</p>
2.1.6	Outline the role of hemoglobin in oxygen transportation.	2	
2.1.7	Explain the process of gaseous exchange at the alveoli.	3	

2.2 Structure and function of the cardiovascular system

12 hours

Aim 7: There are numerous technologies used to facilitate direct measurement in cardiovascular research, for example, interfaced heart rate monitors, blood pressure monitors, ECG monitors.

Assessment statement	Obj	Teacher's notes
2.2.1 State the composition of blood.	1	Blood is composed of cells (erythrocytes, leucocytes and platelets) and plasma. Blood is also the transport vehicle for electrolytes, proteins, gases, nutrients, waste products and hormones.
2.2.2 Distinguish between the functions of erythrocytes, leucocytes and platelets.	2	
2.2.3 Describe the anatomy of the heart with reference to the heart chambers, valves and major blood vessels.	2	The names of the four chambers, four valves (atrio-ventricular and semi-lunar) and the four major blood vessels of the pulmonary and systemic circulation are required. The heart has its own blood supply via the coronary arteries, however the names of the coronary arteries are not required.
2.2.4 Describe the intrinsic and extrinsic regulation of heart rate and the sequence of excitation of the	2	The heart has its own pacemaker, but heart rate is also influenced by the sympathetic

heart muscle.

and parasympathetic branches of the autonomic nervous system and by adrenaline. (It should be recognized that adrenaline has wider metabolic actions, ie increasing glycogen and lipid breakdown). The electrical impulse is generated at the sinoatrial node and travels across the atrium to the atrio-ventricular node via the bundle of His to the ventricles.

2.2.5 Outline the relationship between the pulmonary and systemic circulation. 2

2.2.6 Describe the relationship between heart rate, cardiac output and stroke volume at rest and during exercise. 2

Cardiac output = stroke volume x heart rate. Stroke volume expands and heart rate increases during exercise.

2.2.7 Analyse cardiac output, stroke volume and heart rate data for different populations at rest and during exercise. 3

Limit to males, females, trained, untrained, young and old. Recall of quantitative data is not expected.

2.2.8 Explain cardiovascular drift. 3

An increase of body temperature results in a lower venous return to the heart, a small decrease in blood volume from sweating. A reduction in stroke volume causes the heart rate to increase to maintain cardiac output. Include reference to blood viscosity.

2.2.9 Define the terms *systolic* and *diastolic blood pressure*. 1

Systolic-the force exerted by blood on arterial walls during ventricular contraction. Diastolic-the force exerted by blood on arterial walls during ventricular relaxation.

2.2.10 Analyse systolic and diastolic blood pressure data at rest and during exercise. 3

Recall of quantitative data is not expected.

2.2.11 Discuss how systolic and diastolic blood pressure respond to dynamic and static exercise. 3

2.2.12 Compare the distribution of blood at rest and the redistribution of blood during exercise. 2

Movement of blood in favour of muscles.

2.2.13 Describe the cardiovascular adaptations resulting from endurance exercise training. 2

Limit to increased left ventricular volume resulting in an increased stroke volume and a lower resting and exercising heart rate. Consider also increased capillarization and increased arterio-venous oxygen difference.

2.2.14 Explain maximal oxygen consumption. 3

Maximal oxygen consumption ($\text{VO}_{2\text{max}}$) represents the functional capacity of the oxygen transport system and is sometimes referred to as maximal aerobic power or aerobic capacity.

2.2.15 Discuss the variability of maximal oxygen 3

Consider endurance-trained versus non-

consumption in selected groups.

trained, males versus females, young versus old.

2.2.16 Discuss the variability of maximal oxygen consumption with different modes of exercise.

3

Consider cycling versus running versus arm ergometry.

Topic 3: Energy systems (13 hours)

3.1 Nutrition

4 hours

Assessment statement	Obj	Teacher's notes
3.1.1 List the macronutrients and micronutrients.	1	Macro—lipid (fat), carbohydrate, water and protein. Micro—vitamins, minerals and fibre.
3.1.2 Outline the roles of macronutrients and micronutrients.	2	Specific knowledge of individual vitamins and minerals is not required.
3.1.3 State the chemical composition of a glucose molecule.	1	C, H and O (1:2:1 ratio)
3.1.4 Identify a diagram representing the basic structure of a glucose molecule.	2	
3.1.5 Explain how glucose molecules can combine to form disaccharides and polysaccharides.	3	Condensation reaction—the linking of two monosaccharides by the removal of a water molecule.
3.1.6 State the composition of a molecule of triacylglycerol.	1	Limit to glycerol and three fatty acids.
3.1.7 Distinguish between <i>saturated</i> and <i>unsaturated fatty acids</i> .	2	
3.1.8 State the chemical composition of a protein molecule.	1	Limit to C, H, O and N.
3.1.9 Distinguish between an <i>essential</i> and a <i>non-essential amino acid</i>.	2	<p>Essential amino acids can be synthesised by the human body</p> <p>Non-essential amino acids cannot be synthesised by the human body and must be obtained from diet.</p>

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3.1.10 Describe current recommendations for a healthy 2
balanced diet.

Consider recommendations for carbohydrates, proteins, lipids, fibre, water and salt for adults in the general population. The relative contribution of carbohydrate, protein and lipid (including mono-, poly- and saturated) should be given.

Aim 9: Recommended intakes of nutrients have been published in some countries. The recommendations vary and this raises questions about how the levels are decided.

International dimension/Aim 8: Students can be made aware of the sociocultural influences of food selection and preparation across populations, for example, Mediterranean, Japanese, Western (USA, UK) and Indian.

TOK: Justification of how a balanced diet is defined.

3.1.11 State the energy content per 100 g of 1
carbohydrate, lipid and protein.

Students should know that the energy content values per 100 g are: carbohydrate 1760 kJ, lipid 4000 kJ and protein 1720 kJ.

3.1.12 Discuss how the recommended energy 3
distribution of the dietary macronutrients differs between endurance athletes and non-athletes.

Limit to the important difference in carbohydrate intake and how therefore this also affects fat and protein intake.

International dimension: Variation between countries, for example, a high carbohydrate diet consumed by athletes in some countries.

Aim 8: Some sports require smaller stature therefore diet manipulation may occur prior to competition.

TOK: Justification of how diet contributes to performance.

3.2 Carbohydrate and fat metabolism

2 hours

Assessment statement	Obj	Teacher's notes
3.2.1 Outline the terms <i>metabolism</i> , <i>anabolism</i> , <i>aerobic catabolism</i> and <i>anaerobic catabolism</i> .	2	
3.2.2 State what glycogen is and its major storage sites.	1	
3.2.3 State the major sites of triglyceride storage.	1	Adipose tissue and skeletal muscle.
3.2.4 Explain the role of insulin in the formation of glycogen and the accumulation of body fat.	3	
3.2.5 Outline the terms <i>glycogenolysis</i> and <i>lipolysis</i> .	2	

3.2.6 Outline the functions of glucagon and adrenaline 2
during fasting and exercise.

3.2.7 Explain the role of insulin and muscle 3
contraction on glucose uptake during exercise.

Emphasize that both insulin and muscle contraction stimulate glucose uptake into skeletal muscle.

3.3 Nutrition and energy systems

7 hours

Assessment statement	Obj	Teacher's notes
3.3.1 Annotate the ultrastructure of a generalized animal cell.	2	The diagram should show ribosomes, rough endoplasmic reticulum, lysosomes, Golgi apparatus, mitochondrion and nucleus.
3.3.2 Identify the ultrastructure of a mitochondrion.	2	Cristae, inner matrix and outer smooth membrane
3.3.3 Define the term <i>cell respiration</i> .	1	Cell respiration—the controlled release of energy in the form of ATP from organic compounds in cells.
3.3.4 Explain how adenosine can gain and lose a phosphate molecule.	3	
3.3.5 Explain the role of ATP in muscle contraction.	3	Limit to the breakdown of ATP to ADP releasing a phosphate molecule, which provides energy for muscle contraction. Cross reference with 4.1.3.
3.3.6 Describe the re-synthesis of ATP by the ATP–CP system.	2	Creatine phosphate (a high energy molecule) is broken down to provide a phosphate molecule for the re-synthesis of ATP that has been utilized during the initial stages of exercise.
3.3.7 Describe the production of ATP by the lactic acid system.	2	Also known as anaerobic glycolysis—the breakdown of glucose to pyruvate without the use of oxygen. Pyruvate is then converted into lactic acid, which limits the amount of ATP produced (2 ATP molecules).
3.3.8 Explain the phenomena of oxygen deficit and oxygen debt.	3	Oxygen debt is now known as excess post-exercise oxygen consumption (EPOC).
3.3.9 Describe the production of ATP from glucose and fatty acids by the aerobic system.	2	Limit to: in the presence of oxygen pyruvate is processed by the Krebs cycle which liberates electrons that are passed through the electron transport chain producing energy (ATP). Fats are also broken down by beta oxidation that liberates a greater number of electrons thus more ATP. In the presence of oxygen and in extreme cases protein is also utilized.

3.3.10 Discuss the characteristics of the three energy systems and their relative contributions during exercise.	3	Limit to fuel sources, duration, intensity, amount of ATP production and by-products.
3.3.11 Evaluate the relative contributions of the three energy systems during different types of exercise.	3	Energy continuum. Different types of exercise (endurance athlete, games player, sprinter) should be considered.

Topic 4: Movement analysis (15 hours)

4.1 Neuromuscular function

4 hours

Assessment statement	Obj	Teacher's notes
4.1.1 Label a diagram of a motor unit.	1	Limit to dendrite, cell body, nucleus, axon, motor end plate, synapse and muscle.
4.1.2 Explain the role of neurotransmitters in stimulating skeletal muscle contraction.	3	Limit to acetylcholine and cholinesterase.
4.1.3 Explain how skeletal muscle contracts by the sliding filament theory.	3	Include the terms myofibril, myofilament, sarcomere, actin and myosin, H zone, A band, Z line, tropomyosin, troponin, sarcoplasmic reticulum, calcium ions and ATP. Aim 7: Various online muscle contraction simulations are available.
4.1.4 Explain how slow and fast twitch fibre types differ in structure and function.	3	Limit fibre types to slow twitch (type I) and fast twitch (type IIa and type IIb). Aim 8: Implications of invasive techniques for taking samples, i.e. muscle biopsies. Aim 9: Implications of drawing conclusions from indirect measurements.

4.2 Joint and movement type

3 hours

Assessment statement	Obj	Teacher's notes
4.2.1 Outline the types of movement of synovial joints.	2	Consider flexion, extension, abduction, adduction, pronation, supination, elevation, depression, rotation, circumduction, dorsi flexion, plantar flexion, eversion and inversion.
4.2.2 Outline the types of muscle contraction.	2	Consider isotonic, isometric, isokinetic, concentric and eccentric.
4.2.3 Explain the concept of reciprocal inhibition.	3	Consider agonist and antagonist.

- 4.2.4 Analyse movements in relation to joint action and muscle contraction. 3 For example, during the **upward motion** of a bicep curl the joint action is flexion. The bicep contracts concentrically while the tricep **relaxes** eccentrically.
- 4.2.5 Discuss delayed onset of muscle soreness (DOMS) in relation to eccentric and concentric muscle contractions. 3

4.3 Fundamentals of biomechanics

8 hours

In this sub-topic, no calculations are required.

Assessment statement	Obj	Teacher's notes
4.3.1 Define the terms <i>force</i> , <i>speed</i> , <i>velocity</i> , <i>displacement</i> , <i>acceleration</i> , <i>momentum</i> and <i>impulse</i> .	1	Encourage the use of vectors and scalars.
4.3.2 Analyse velocity–time, distance–time and force–time graphs of sporting actions.	3	
4.3.3 Define the term <i>centre of mass</i> .	1	
4.3.4 Explain that a change in body position during sporting activities can change the position of the centre of mass.	3	Consider one example of an activity where the centre of mass remains within the body throughout the movement and one activity where the centre of mass temporarily lies outside the body. Students should understand the changes in body position and centre of mass pathway.
4.3.5 Distinguish between <i>first</i> , <i>second</i> and <i>third class levers</i> .	2	
4.3.6 Label anatomical representations of levers.	1	Limit to the triceps–elbow joint, calf–ankle joint and biceps–elbow joint. Students will be expected to indicate effort, load, fulcrum and the muscles and bones involved.
4.3.7 Define Newton's three laws of motion.	1	
4.3.8 Explain how Newton's three laws of motion apply to sporting activities.	3	For example, consider how Newton's second and third laws enable an athlete to accelerate out of starting blocks. Impulse momentum relationship. The Law of Conservation of Momentum should also be considered.
4.3.9 State the relationship between angular momentum, moment of inertia and angular velocity.	1	
4.3.10 Explain the concept of angular momentum in relation to sporting activities.	3	Include consideration of moments of inertia, major axes of rotation and an appreciation of the law of conservation of angular momentum.

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4.3.11 State and explain the factors that affect projectile motion at take-off or release .	1,3	Include speed of release, height of release and angle of release
4.3.12 Outline the Bernoulli principle with respect to projectile motion in sporting activities.	2	<p>Consider how airflow affects the golf ball and discuss, and one other example.</p> <p>The Bernoulli principle states that pressure is inversely proportional to the velocity of a fluid. When airflow is passing over, under or around an object, this results in a pressure differential.</p> <p>A ball can be deflected towards the direction of the spin or the side in which there is a lower pressure area, and this is known as the Magnus effect.</p> <p>Aim 7: Still photography and video can be used to record and analyse movement.</p> <p>A visit to a university may be possible to see the use of high-speed photography, photoelectric cells and motion analysis software.</p>

Topic 5: Skill in sport (15h)

5.1 The characteristics and classification of skill

4 hours

Assessment statement	Obj	Teacher's notes
5.1.1 Define the term <i>skill</i> .	1	Skill is the consistent production of goal-oriented movements, which are learned and specific to the task (McMorris 2004).
5.1.2 Describe the different types of skill.	2	Limit to cognitive, perceptual, motor and perceptual motor skills.
5.1.3 Outline the different approaches to classifying <u>motor skills</u> .	2	Limit to (i) gross-fine, (ii) open-closed, (iii) discrete-serial-continuous (iv) external-internal paced skills (v) interaction continuum (individual-coactive-interactive).
5.1.4. Compare skill profiles for contrasting sports.	3	Using the continua in 5.1.3, compare contrasting sports.
5.1.5 Define the term <i>ability</i> .	1	<p>Ability is a stable, enduring characteristic, that is genetically determined and may be wholly perceptual, wholly motor or a combination—psychomotor.</p> <p>It should be appreciated that abilities underpin specific skills.</p> <p>TOK: Current research considers that abilities will change with time.</p>

5.1.6 Distinguish between Fleishman's <i>physical proficiency abilities</i> (physical factors) and <i>perceptual motor abilities</i> (psychomotor factors).	2	Fleishman (1972) distinguishes between physical proficiency and perceptual motor ability. Recall of the individual abilities is not required.
5.1.7 Define the term <i>technique</i> .	1	Technique in general terms is a 'way of doing'. In the performance of a specific sports skill it is defined as the 'way in which that sports skill is performed'.
5.1.8 State the relationship between ability, skill, and technique.	1	Skill = ability + selection of an appropriate technique
5.1.9 Discuss the differences between a skilled and a novice performer.	3	Limit to consistency, accuracy, control, learned, efficiency, certainty, goal-directed and fluency.

5.2 Information processing

6 hours

Assessment statement	Obj	Teacher's notes
5.2.1 Describe a simple model of information processing.	2	Information processing is the system by which we take information from our surrounding environment, use it to make a decision and then produce a response: input–decision-making–output. All the approaches are only models. Input and output are assessable/observable, but the decision-making process can only be speculation.
5.2.2 Describe Welford's model of information processing.	2	Welford's model (1968) includes: (i) sense organs (ii) perception (iii) short-term memory (iv) long-term memory (v) decision making (vi) effector control (vii) feedback.
5.2.3 Outline the components associated with sensory input.	2	Consider exteroceptors, proprioceptors and introceptors.
5.2.4 Explain the signal detection process.	3	Often referred to as the detection–comparison–recognition process (DCR). Limit to background noise, intensity of the stimulus, efficiency of the sense organs, early signal detection and improving signal detection.
5.2.5 Distinguish between the characteristics of <i>short-term sensory store</i> , <i>short-term memory</i> and <i>long-term memory</i> .	2	Limit to capacity, duration and retrieval.
5.2.6 Discuss the relationship between selective attention and memory.	3	Limit to short-term sensory store, role of short- and long-term memory in signal detection, selective attention (intentional and involuntary attention), filtering, channel capacity (single channel hypothesis/series or parallel), information

			overload and experience.
5.2.7	Compare different methods of memory improvement.	3	Limit to rehearsal, coding, brevity, clarity, chunking, organization, association and practice.
5.2.8	Define the term <i>response time</i> .	1	Response time = reaction time + movement time. Aim 7: Use of online methods of measuring response time.
5.2.9	Outline factors that determine response time.	2	Response time is an ability, having individual and group variance (for example, gender and age). Reaction time includes stimulus transmission, detection, recognition, decision to respond, nerve transmission time and initiation of action. Include consideration of Hick's Law.
5.2.10	Evaluate the concept of the psychological refractory period (PRP).	3	Include the single channel mechanism and how PRP helps to explain deception in sport.
5.2.11	Describe a motor programme.	2	Defined as a set of movements stored as a whole in the memory regardless of whether feedback is used in their execution. Limit to: (i) a whole plan (executive programme/motor programme) and subroutines (ii) coordination of subroutines (iii) relegating executive programmes to subroutines.
5.2.12	Compare motor programmes from both open and closed loop perspectives.	3	Include Adam's concepts of memory trace and perceptual trace.
5.2.13	Explain Schmidt's schema theory.	3	Include recall schema and recognition schema and the role of short-term memory and long-term memory.
5.2.14	Outline the role of feedback in information processing models.	2	Limit to: (i) intrinsic, extrinsic (ii) knowledge of results, knowledge of performance (iii) positive, negative (iv) concurrent, terminal.
5.2.15	Outline the role of feedback with the learning process.	2	Limit to reinforcement of learning, motivation, adaptation of performance and punishment.

5.3 Principles of skill learning

5 hours

	Assessment statement	Obj	Teacher's notes
5.3.1	Distinguish between <i>learning</i> and	2	Learning is a relatively permanent change in performance brought about by

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performance.

experience, excluding changes due to maturation and degeneration.

Performance is a temporary occurrence, fluctuating over time.

A change in performance over time is often used to infer learning.

5.3.2	Describe the phases (stages) of learning.	2	Cognitive/verbal (early phase), associative/motor (intermediate phase), and autonomous (final phase).
5.3.3	Outline the different types of learning curves.	2	Limit to: (i) positive acceleration (ii) negative acceleration (iii) linear (iv) plateau.
5.3.4	Discuss factors that contribute to the different rates of learning.	3	Limit to physical maturation, physical fitness, individual differences of coaches, age, difficulty of task, teaching environment and motivation.
5.3.5	Define the concept of <i>transfer</i> .	1	
5.3.6	Outline the types of transfer.	2	Limit to positive and negative, as they apply to: <ul style="list-style-type: none"> • skill to skill • practice to performance • abilities to skills • bilateral • stage to stage • principles to skills. Refer to an example in each case.
5.3.7	Outline the different types of practice.	2	Limit to distributed, massed, fixed (drill), variable and mental.
5.3.8	Explain the different types of presentation.	3	Limit to whole, whole–part–whole, progressive part and part. Refer to an example in each case.
5.3.9	Outline the spectrum of teaching styles.	2	Limit to command, reciprocal and problem solving.

Topic 6: Measurement and evaluation of human performance (13 hours)

6.1 Statistical analysis

2 hours

	Assessment statement	Obj	Teacher's notes
6.1.1	Outline that error bars are a graphical representation of the variability of data.	2	Error bars can denote standard deviation, standard error of the mean or confidence intervals. Only standard deviation needs to be considered.
6.1.2	Calculate the mean and standard deviation of a set of values.	2	<p>Students should specify the sample standard deviation, not the population standard deviation.</p> <p>Students will not be expected to know the formulas for calculating these statistics. They will be expected to use the statistics function of a graphic display or scientific calculator.</p> <p>Aim 7: Students could also be taught how to calculate SD using a spreadsheet computer program.</p>
6.1.3	State that the statistic standard deviation is used to summarize the spread of values around the mean, and that within a normal distribution approximately 68% and 95% of the values fall within plus or minus one or two standard deviations respectively.	1	For normally distributed data, about 68% of all values lie within ± 1 standard deviation of the mean. This rises to about 95% for ± 2 standard deviations.
6.1.4	Explain how the standard deviation is useful for comparing the means and the spread of data between two or more samples.	3	A small standard deviation indicates that the data is clustered closely around the mean value. Conversely, a large standard deviation indicates a wider spread around the mean.
6.1.5	Outline the meaning of coefficient of variation.	2	Coefficient of variation is the ratio of the standard deviation to the mean expressed as a percentage.
6.1.6	Deduce the significance of the difference between two sets of data using calculated values for t and the appropriate tables.	3	<p>For the t-test to be applied, ideally the data should have a normal distribution and a sample size of at least 10. The t-test can be used to compare two sets of data and measure the amount of overlap. Students will not be expected to calculate values of t. Only two-tailed, paired and unpaired t-tests are expected.</p> <p>Aim 7: While students are not expected to calculate a value for the t-test, students could be shown how to calculate such</p>

values using a spreadsheet program or the graphic display calculator.

TOK: The scientific community defines an objective standard by which claims about data can be made.

- 6.1.7 Explain that the existence of a correlation does not establish that there is a causal relationship between two variables. 3

Aim 7: While calculations of such values are not expected, students who want to use r and r^2 values in their practical work could be shown how to determine such values using a spreadsheet program.

6.2 Study design

4 hours

	Assessment statement	Obj	Teacher's notes
6.2.1	Outline the importance of specificity, 2 accuracy, reliability and validity with regard to fitness testing.		
6.2.2	Discuss the importance of study design in the 3 context of the sport and exercise sciences.		This should include a demonstration of causality by the inclusion of control groups, randomization, placebos, blinding and double-blinding.
6.2.3	Outline the importance of the Physical 2 Activity Readiness Questionnaire (PAR-Q).		
6.2.4	Discuss the advantages and disadvantages 3 of field, laboratory, sub-maximal and maximal tests of human performance.		

6.3 Components of fitness

4 hours

	Assessment statement	Obj	Teacher's notes
6.3.1	Distinguish between the concepts of <i>health-related fitness</i> and <i>performance-related</i> (skill-related) fitness.	2	Health related fitness includes body composition, cardio-respiratory fitness (aerobic capacity), flexibility, muscular endurance, strength Performance-related (skill-related) fitness includes agility, balance coordination, power, reaction time and speed.
6.3.2	Outline the major components of fitness identified in 6.3.1.	2	

6.3.3 Outline and evaluate a variety of fitness tests. 2,3

Consider validity, reliability and limitations of the following tests.

Aerobic capacity—multistage fitness test/beep test (Leger Test), Cooper's 12 Minute Run, Harvard Step Test

Flexibility—sit and reach

Muscle endurance —maximum sit-ups, maximum push-ups, flexed arm hang

Agility—Illinois Agility Test

Strength—hand grip dynamometer

Speed—40 metre sprint

Body composition—body mass index, anthropometry and underwater weighing

Balance—stork stand

Coordination—hand ball toss

Reaction time—drop test, **computer simulation**

Power—vertical jump, standing broad jump

Aim 9: Issues of using direct and indirect measures of fitness, and the extrapolation of data and generalizations across populations could be considered. Cultural variations in the establishment of standardized norms may also be explored.

Aim 7: **Opportunity to use computer simulation/modelling and databases.**

6.4 Principles of training programme design

3 hours

	Assessment statement	Obj	Teacher's notes
6.4.1	Describe the essential elements of a general training programme.	2	<p>This should include warm-up and stretching activities, endurance training, cool down and stretching activities, flexibility training, resistance training and the incorporation of recreational activities and sports into the schedule.</p> <p>TOK: Recent research questions the effectiveness of static stretching as a necessary component of the warm-up. The difficulty of conducting controlled trials without a placebo effect could be discussed. The willingness of athletes to believe what they are told, without questioning the advice, could also be considered.</p>
6.4.2	Discuss the key principles of training programme design.	3	<p>Limit to progression, overload (frequency, intensity and duration), specificity, reversibility and variety.</p>
6.4.3	Outline ways in which exercise intensity can be monitored.	2	<p>Limit to:</p> <ul style="list-style-type: none"> • use of heart rate based upon its relationship with oxygen uptake, ie target heart rate that coincides with a given percentage of maximal oxygen uptake • the Karvonen method • the training heart rate range/zone • ratings of perceived exertion (Borg/OMNI/CERT scale).

Syllabus content—Options

A	Optimizing physiological performance	15
B	Psychology of sport	15
C	Physical activity and health	15
D	Nutrition for sport, exercise and health	15

Option A: Optimizing physiological performance

A.1 Training

5 hours

	Assessment statement	Obj	Teacher's notes
A.1.1	Distinguish between <i>training</i> , <i>overtraining</i> and <i>over-reaching</i> .	2	<p>Training is performing exercise in an organized manner on a regular basis with a specific goal in mind (cross reference with 6.2).</p> <p>Overtraining is when an athlete attempts to do more training than he or she is able to physically and/or mentally tolerate. Overtraining results in a number of symptoms that are highly individualized.</p> <p><i>Over-reaching is transient over-training.</i></p>
A.1.2	Describe various methods of training.	2	<p>Limit to:</p> <ul style="list-style-type: none"> flexibility training strength and resistance training circuit training interval training plyometrics continuous training fartlek training / <i>speed play</i> cross training.
A.1.3	Discuss possible indicators of overtraining.	3	<p>Limit to changes to resting heart rate, chronic muscle soreness, reduced immune function and frequent upper-respiratory tract</p>

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			infections (coughs and colds), sleep disturbance, fatigue, decreased appetite, sudden and unexplained decrease in performance.
A.1.4	Discuss how periodization should be organized to optimize performance and avoid overtraining and injury.	3	Periodization—transition (post-season), preparation (pre-season), competition. Knowledge of macrocycle, mesocycle and microcycle is required.

A.2 Environmental factors and physical performance

6 hours

	Assessment statement	Obj	Teacher's notes
A.2.1	Explain the relationship between cellular metabolism and the production of heat in the human body.	3	Include consideration of the meaning of efficiency with regard to energy liberation, ATP re-synthesis and heat production.
A.2.2	State the normal physiological range for core body temperature.	1	
A.2.3	Outline how the body thermoregulates in hot and cold environments.	2	Include the principles of conduction, convection, radiation and evaporation. International dimension: The ability of people who habitually live in very cold/hot climates to tolerate these harsh conditions compared with people who live in temperate climates could be considered.
A.2.4	Discuss the significance of humidity and wind in relation to body heat loss.	3	
A.2.5	Describe the formation of sweat and the sweat response.	2	Consideration of the role of the sympathetic nervous system and the hypothalamus is not required.
A.2.6	Discuss the physiological responses that occur during prolonged exercise in the heat.	3	Limit this to cardiovascular response (cross reference with 2.2.8), energy metabolism* and sweating. * The reduced muscle blood flow in high temperatures results in increased glycogen breakdown in the muscle and higher levels of muscle and blood lactate in comparison to the same exercise performed in a cooler environment.
A.2.7	Discuss the health risks associated with exercising in the heat.	3	Heat-related disorders include heat cramps, heat exhaustion and heat stroke. Because of their relatively large body surface area and immature sweat response, infants, children and young adolescents are more susceptible to complications associated with exercise performed in the heat and the cold.
A.2.8	Outline what steps should be taken to prevent	2	

and to subsequently treat heat-related disorders.

- | | | | |
|--------|---|---|--|
| A.2.9 | Describe how an athlete should acclimatize to heat stress. | 2 | <p>Performing training sessions in similar environmental conditions (heat and humidity) for 5 to 10 days results in almost total heat acclimatization. Initially, the intensity of training should be reduced to avoid heat-related problems in these conditions.</p> <p>National representative teams/sportspeople choosing to acclimatize to the conditions of a host country during a major international sporting competition could be considered.</p> <p>Aim 8: The cost associated with the acclimatization of athletes using environmental chambers and/or expensive overseas training facilities (science and technology drives demand) could be explored. This also raises an ethical implication that poorer nations will be unable to afford such support mechanisms and so their athletes are disadvantaged in comparison to athletes from wealthier nations.</p> |
| A.2.10 | Discuss the physiological adaptations that occur with heat acclimatization. | 3 | <p>Include increased plasma volume, increased sweat response and reduced rate of muscle glycogen utilization.</p> |
| A.2.11 | Outline the principal means by which the body maintains core temperature in cold environments. | 2 | <p>Consider shivering, non-shivering thermogenesis and peripheral vasoconstriction.</p> |
| A.2.12 | Explain why the body surface area-to-body mass ratio is important in terms of heat preservation. | 3 | <p>For example, tall, heavy individuals have a small body surface area-to-body mass ratio which makes them less susceptible to hypothermia.</p> <p>Small children tend to have a large body surface area-to-body mass ratio compared to adults. This makes it more difficult for them to maintain normal body temperature in the cold.</p> |
| A.2.13 | Outline the importance of wind-chill in relation to body heat loss. | 2 | <p>A chill factor created by the increase in the rate of heat loss via convection and conduction caused by wind.</p> |
| A.2.14 | Explain why swimming in cold water represents a particular challenge to the body's ability to thermoregulate. | 3 | <p>Consider the thermal conductivity of water and air.</p> <p>During cold-water immersion, humans generally lose body heat and become hypothermic at a rate proportional to the thermal gradient and the duration of exposure. During swimming, the effect of cold water on body heat loss is increased because of greater convective heat loss. However, at high swimming speeds, the</p> |

			metabolic rate of the swimmer may compensate for the increased heat loss.
A.2.15	Discuss the physiological responses to exercise in the cold.	3	Limit this to muscle function and metabolic responses.
A.2.16	Describe the health risks of exercising in the cold, including cold water.	2	Limit to frostbite and hypothermia.
A.2.17	Discuss the precautions that should be taken when exercising in the cold.	2	<p>The principal barrier is clothing, the amount of insulation offered by which is measured in a unit called a clo. Generally each 0.6 cm of clothing adds 1 clo of insulation. The insulating effect of clothing is reduced when it becomes wet. Overdressing during exercise also enhances heat loss; wearing too many layers increases heat production and sweating. As the sweat soaks through the clothing and evaporates, heat is lost. In extremely cold conditions, exposed skin on the hands and face should also be covered. Cold, dry air can constrict the bronchioles and induce a cough.</p> <p>Consideration of exercising in water is not required.</p>

A.3 Non-nutritional ergogenic aids

4 hours

Aim 8: There are clear ethical issues in the use of performance enhancing drugs.

	Assessment statement	Obj	Teacher's notes
A.3.1	Define the term <i>ergogenic aid</i> .	1	An ergogenic aid is any substance or phenomenon that improves an athlete's performance.
A.3.2	Describe, with reference to an appropriate example, the placebo effect.	2	
A.3.3	List five classes of non-nutritional ergogenic aids that are currently banned by the International Olympic Committee (IOC) and World Anti-Doping Agency (WADA).	1	<p>Specific names of banned substances need not be given. Limit to:</p> <ul style="list-style-type: none"> • anabolic steroids • hormones and related substances • diuretics and masking agents • beta blockers • stimulants.
A.3.4	Discuss why pharmacological substances appear on the list of banned substances.	3	The discussion should focus on the moral obligation of athletes to compete fairly and on the safety issue around the use of these substances.
A.3.5	Discuss the proposed and actual benefits that some athletes would hope to gain by using	3	The combined effects of taking two or

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anabolic steroids, erythropoietin (EPO), beta blockers, caffeine and diuretics.

more of the above need not be considered.

TOK: Decisions about what constitutes an acceptable level of risk could be discussed, together with differences between different groups and their views—scientists, sportsmen, doctors and spectators.

A.3.6 Outline the possible harmful effects of long-term use of anabolic steroids, EPO, beta blockers, caffeine and diuretics. 2

TOK: Our understanding of the effects, both ergogenic and harmful, of many banned substances, for example, anabolic steroids, has been hindered by the ethical concerns/problems about studying these agents in otherwise healthy individuals in randomized controlled trials.

Option B: Psychology of sport

B.1 Individual differences

5 hours

	Assessment statement	Obj	Teacher's notes
B.1.1	Define the term <i>personality</i> .	1	<p>There are many definitions of personality; for the purpose of this course the following definition will be used.</p> <p>"Those relatively stable and enduring aspects of individuals which distinguish them from other people, making them unique but at the same time permit a comparison between individuals". (Gross, 1992)</p> <p>TOK: There is significant disagreement in personality research regarding issues of validity, reliability and sophistication of theoretical models.</p>
B.1.2	Discuss social learning theory and personality.	3	Limit to Bandura's (1977) social learning theory.
B.1.3	Discuss the interactionist approach to personality.	3	
B.1.4	Outline issues associated with the measurement of personality.	2	<p>Limit to:</p> <ul style="list-style-type: none"> • data collection (interviews, questionnaires, observing behaviour) • validity and reliability issues • ethical issues: confidentiality, use of results, predicting performance. <p>TOK: Issues relating to measurement.</p>
B.1.5	Evaluate the issues in personality research and sports performance.	3	Consider athletes versus non-athletes, personality and sport type, predicting performance. Refer to the positions adopted by the skeptical and credulous groups of psychologists.

B.2 Motivation

3 hours

	Assessment statement	Obj	Teacher's notes
B.2.1	Define the term <i>motivation</i> .	1	Motivation is "the internal mechanisms and external stimuli which arouse and direct our behaviour" (Sage, 1974).
B.2.2	Outline the types of motivation.	2	Limit to intrinsic and extrinsic motivation theory.
B.2.3	Discuss the issues associated with combining 3 intrinsic and extrinsic motivators.	3	Limit to how extrinsic rewards influence intrinsic motivation. Extrinsic rewards seen as controlling of behaviour. Extrinsic rewards providing information about their level of performance. Extrinsic rewards will enhance intrinsic motivation when the reward provides positive information with regard to the performer's level of competence.
B.2.4	Describe Atkinson's model of Achievement Motivation.	2	
B.2.5	Outline Goal Orientation theory.	2	Limit to: <ul style="list-style-type: none"> • reasons for participation (achievement goals) • differing meanings that success or failure has for the performer (task versus outcome orientation).
B.2.6	Describe Attribution Theory and its application to sport and exercise.	2	Limit to Weiner's classification for causal attributions. <ul style="list-style-type: none"> • Locus of stability • Locus of causality • Locus of control • Self-serving bias • Learned helplessness

B.3 Mental preparation for sport

4 hours

	Assessment statement	Obj	Teacher's notes
B.3.1	Define the term <i>arousal</i> .	1	
B.3.2	Describe the theoretical approaches to arousal.	2	Limit to: <ul style="list-style-type: none"> • drive reduction theory

			<ul style="list-style-type: none"> inverted-U hypothesis catastrophe theory.
B.3.3	Draw and label a graphical representation of the arousal performance relationship.	1	Refer to the theories of arousal in B.3.2.
B.3.4	Discuss the emotions that may influence an athlete's performance or experience in a physical activity.	3	<p>Limit to a discussion of the emotions that may be prevalent in physical activity. This may include:</p> <ul style="list-style-type: none"> positive emotions such as excitement, relief, pride, provocativeness negative emotions such as anger, guilt, shame, anxiety, boredom specific emotions that have a discrete effect on performance.
B.3.5	Define the term <i>anxiety</i> .	1	
B.3.6	Distinguish between <i>cognitive</i> and <i>somatic anxiety</i> .	2	
B.3.7	Distinguish between <i>trait</i> and <i>state anxiety</i> .	2	
B.3.8	Evaluate how anxiety is measured.	3	<p>Limit to:</p> <ul style="list-style-type: none"> trait anxiety: Sport Competition Anxiety Test (SCAT) state anxiety: Competitive State Anxiety Inventory (CSAI-2R). <p>TOK: Issues relating to measurement.</p>
B.3.9	Describe the stress process in sport.	2	<p>Defined as a substantial imbalance between the demand (physical and/or psychological) and response capability, under conditions where failure to meet that demand has important consequences.</p> <p>Include: (i) causes of stress (environmental demand), (ii) stress response (person's reactions), (iii) stress experience (psychological interpretation) (iv) actual behaviour (outcome).</p>

B.4 Psychological skills training

3 hours

The competitive process is complex and multifaceted. A performer is affected by a range of factors (personality, motivation, arousal, emotional affect). One aim of a sports psychologist is to manipulate these factors to enhance optimal performance. This section examines several fundamental interventions and evaluates their benefits and limitations.

Assessment statement	Obj	Teacher's notes
B.4.1	Discuss psychological skills training (PST).	3 Refers to the systematic and consistent practice of mental or psychological skills.

			<p>Include the following issues. PST: (i) is not just for elite athletes (ii) is not just for problem athletes (iii) does not provide quick fix solutions.</p> <p>Consider the three phases of a PST programme: (i) education (ii) acquisition (iii) practice.</p>
B.4.2	Outline goal setting.	2	<p>Include:</p> <ul style="list-style-type: none"> • associated with enhancing self-confidence and motivation • SMARTER (specific, measurable, achievable, realistic, time, exciting, review) goals • types of goals (outcome, performance, process).
B.4.3	Evaluate mental imagery.	3	<p>Associated with concentration enhancement, self-confidence, skill acquisition, emotional control, practice strategy and coping with pain and injury.</p> <p>Include:</p> <ul style="list-style-type: none"> • external and internal imagery • protocol for imagery interventions.
B.4.4	Outline relaxation techniques.	2	<p>Associated with arousal regulation, reducing somatic and cognitive anxiety.</p> <p>Include: (i) progressive muscular relaxation (PMR) (ii) breathing techniques (iii) biofeedback.</p>
B.4.5	Outline self-talk techniques.	2	<p>Associated with concentration, attention, cognitive regulation and motivation enhancement.</p> <p>Include:</p> <ul style="list-style-type: none"> • positive and negative self-talk • thought stopping.

Option C: Physical activity and health

C.1 Hypokinetic disease

1.5 hours

	Assessment statement	Obj	Teacher's notes
C.1.1	Distinguish between the terms <i>habitual physical activity</i> , <i>exercise</i> , <i>sport</i> and <i>physical fitness</i> .	2	
C.1.2	Define the term <i>hypokinetic disease</i> .	1	Hypokinetic disease—disease associated with physical inactivity.
C.1.3	Outline the following hypokinetic diseases: coronary heart disease, stroke, hypertension, obesity, type 2 diabetes and osteoporosis.	2	
C.1.4	Discuss how studies of different populations provide evidence of the link between physical activity and hypokinetic disease.	3	Consider how various populations have changed their lifestyles from one of high physical activity (traditional, agricultural-based living) to one of low physical activity ("westernized" living).
C.1.5	Discuss the relationship between major societal changes and hypokinetic disease.	3	Examples of changes include the proliferation of the motor vehicle, changes in employment and working patterns, and changes in diet such as the rise of fast food.

C.2 Cardiovascular disease

3 hours

	Assessment statement	Obj	Teacher's notes
C.2.1	Outline the coronary circulation.	2	Left and right coronary arteries, circumflex artery and left anterior descending artery should be identified.
C.2.2	Outline what is meant by the term <i>atherosclerosis</i> .	2	A detailed explanation of the processes leading to atherosclerosis is not required. The general idea that an artery becomes damaged and blocked with cholesterol and other material (the formation of atherosclerotic plaque) is sufficient.
C.2.3	List the major risk factors for cardiovascular disease.	1	Limit to cigarette smoking, high blood pressure (hypertension), high cholesterol and LDL-cholesterol, low HDL-cholesterol, diabetes, obesity, physical inactivity, age, gender, ethnicity and family history.
C.2.4	Explain the concept of risk factors in cardiovascular disease.	3	Consider the individual and accumulative effects (ie the effects of having one risk factor versus a cluster) of the major risk factors for cardiovascular disease.

TOK: The distinction between correlation and cause could be made here and the need for carefully controlled experiments to test whether a correlation is due to a causal link. An interesting discussion is whether physical inactivity is causal or correlative.

TOK: An interesting topic for consideration is the validity of animal experimentation as a part of the process of uncovering the causes of disease in humans and in the development of new pharmacological treatments.

International dimension: This is clearly a good place to consider differences in cardiovascular disease risk in different populations. There are many examples of where different ethnic groups appear to vary in their susceptibility to cardiovascular disease and this could be considered from the perspective of genes (nature) versus lifestyle (nurture).

Aim 7: Use of sophisticated imaging techniques and technologies could be mentioned here. For example, use of magnetic resonance imaging (MRI) and gamma cameras for capturing information about the extent and anatomical positioning of atherosclerotic plaque.

C.2.5	Discuss how a lifestyle of physical inactivity increases the risk of cardiovascular disease.	3	Discussion of the physiological mechanisms is not required (for example, why inactivity “causes” high blood pressure). Emphasis should be on the concept that people who are physically inactive are more likely to have risk factors for cardiovascular disease. High blood pressure, obesity, type 2 diabetes and low HDL-cholesterol should be considered.
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C.3 Physical activity and obesity

2 hours

Assessment statement		Obj	Teacher’s notes
C.3.1	Describe how <i>obesity</i> is determined.	2	Obesity is by definition an excess of body fat, but in reality obesity is determined using indirect measurements of body fat, for example, body mass index (BMI) and waist girth. The description should be restricted to these two techniques. The BMI values that define normal weight, overweight and obesity are widely accepted. Waist girth values that define abdominal obesity are gender and ethnicity specific and reflect different levels of disease risk in obesity.

			<p>TOK: BMI is the most widely used method of measuring obesity, yet its limitations as a measure of “fatness” is well known.</p> <p>The World Health Organization cut-off points for underweight, overweight, obesity and fat distribution may need revision because the relationship between body mass index and body composition, and between indices of fat distribution and the actual amount of visceral fat, differ across ethnic groups.</p> <p>Aim 8: Obesity, particularly childhood obesity, is associated with social stigmatization and bullying. This raises an ethical issue around the routine, large-scale screening for obesity.</p> <p>Aim 7/Aim 8: Sophisticated imaging techniques such as computed tomography (CT), MRI, and dual energy x-ray (DXA) provide state-of-the-art methods for measuring body fat. However, they are costly, not widely available, and, in the case of CT and DXA, expose the individual to radiation.</p>
C.3.2	Outline the major health consequences of obesity.	2	<p>Limit to: cardiovascular disease and hypertension, type 2 diabetes, osteoarthritis, respiratory problems, some cancers such as bowel cancer. Consideration of the effects of age, gender and ethnicity is not required.</p>
C.3.3	Discuss the concept of energy balance.	3	<p>Energy balance is affected mainly by food intake, resting metabolic rate and physical activity. Consider the effects of positive and negative energy balance on body weight and composition.</p>
C.3.4	Outline how chemical signals arising from the gut and from the adipose tissue affect appetite regulation.	2	<p>Only a simple account is expected.</p> <p>Hormones are produced by the stomach and small intestine after eating and by adipose tissue (leptin). These pass to an appetite control centre in the brain that regulates feelings of hunger and satiety.</p> <p>TOK: Leptin was first discovered in mice and led to the expectation that obesity could be “cured”. Later discoveries in humans have shown that this initial expectation was misplaced. This is a good example of where scientific discoveries can sometimes be taken out of context by the media and lead to false hope by individuals affected by certain conditions.</p>

C.4 Physical activity and type 2 diabetes

2 hours

	Assessment statement	Obj	Teacher's notes
C.4.1	Compare type 1 and type 2 diabetes.	3	Type 1 diabetes is an autoimmune disorder resulting in the destruction of the insulin-producing cells of the pancreas. It usually manifests in young people. Type 2 diabetes is a disease of insulin resistance, particularly in skeletal muscle and is highly related to obesity and older age. Past terms for these disorders include insulin-dependent and non-insulin-dependent diabetes (IDDM and NIDDM), which are no longer used. Consider also the way in which diabetes is treated: type 1 with insulin; type 2 with diet and exercise, oral medication and/or insulin. Other less common forms of diabetes do not need to be discussed. Cross reference 3.2.4.
C.4.2	Discuss the major risk factors for type 2 diabetes.	3	<p>Limit to obesity, physical inactivity, a diet high in saturated fat and family history.</p> <p>TOK: The nature of risk factors and the difficulties of making decisions about the relative influence of nature and nurture could be discussed.</p> <p>International dimension: There are clear differences in susceptibility to type 2 diabetes, with some populations having higher rates of incidence. For example, the experience of the Pima Indians is well documented. This could lead to a wider consideration of the diversity in human societies combined with the need for parity of esteem.</p> <p>Aim 8: Ethical and economic decisions as to who should be treated, ie the blood glucose level at which diabetes is diagnosed could be considered.</p>
C.4.3	Outline the health risks of diabetes.	2	Limit to blindness, kidney disease, nerve damage and cardiovascular disease.

C.5 Physical activity and bone health

2.5 hours

	Assessment statement	Obj	Teacher's notes
C.5.1	Outline how bone density changes from birth to old age.	2	Bone density increases from birth through to around 35–45 years of age. Typically females achieve a lower peak bone density

			than males. From this age onwards bone density decreases.
C.5.2	Describe the risk of osteoporosis in males and females.	2	
C.5.3	Outline the longer-term consequences of osteoporotic fractures.	2	Limit to loss of independence, development of secondary complications as a result of long-term hospitalization and pneumonia.
C.5.4	Discuss the major risk factors for osteoporosis.	3	Limit to lack of dietary calcium, cigarette smoking, slim build (ectomorphy), lack of estrogen associated with early menopause and female triad (athletic amenorrhea) and physical inactivity.
C.5.5	Discuss the relationship between physical activity and bone health.	3	Weight-bearing physical activity is essential for bone health, but in some cases, intense training in weight-conscious athletes gives rise to low body weight/body fat and eating disorders, leading to menstrual dysfunction and bone demineralization (osteoporosis). Changes in bone density are site-specific and resistance training results in greater changes than endurance training. Consideration of the importance of weight-bearing exercise in children should be given.

C.6 Prescription of exercise for health

1.5 hours

	Assessment statement	Obj	Teacher's notes
C.6.1	Outline physical activity guidelines for the promotion of good health	2	Consider current World Health Organisation (WHO) recommendations for minimal levels of physical activity in the promotion of good health.
C.6.2	Describe the aims of exercise in individuals with a hypokinetic disease.	2	Limit to: <ul style="list-style-type: none"> to make the most of limited functional capacities to alleviate or provide relief from symptoms to reduce the need for medication to reduce the risk of disease reoccurrence (secondary prevention) to help overcome social problems and psychological distress.
C.6.3	Discuss the potential physical barriers to physical activity.	3	Limit to: <ul style="list-style-type: none"> uncontrolled disease state (unstable angina, poorly controlled diabetes, uncontrolled hypertension) hazards of exercise (for example, cycle

- and swimming accidents)
- musculoskeletal injuries
- triggering of other health issues (for example, heart attack, respiratory tract infections).

C.7 Exercise and psychological well-being

2.5 hours

	Assessment statement	Obj	Teacher's notes
C.7.1	Define the term <i>mood</i> .	1	A state of emotional or affective arousal of varying, and not permanent, duration. Feelings of elation or happiness lasting several hours or even a few days are examples of mood.
C.7.2	Outline the effects of exercise on changing mood states.	2	Limit to: <ul style="list-style-type: none"> • research suggests exercise is one of the most effective methods of alleviating a bad mood • research supports the use of exercise in modifying fatigue, anger, anxiety, depression, and enhancing the positive moods of vigour, clear thinking, energy, alertness, increased sense of well-being.
C.7.3	Describe how exercise enhances psychological well-being.	2	No single theory explains the process fully. It is likely that an interaction between both physiological and psychological factors underpin the process. Limit to: <ul style="list-style-type: none"> • physiological—increases in cerebral blood flow, changes in brain neurotransmitters (norepinephrine, endorphins, serotonin), increase in maximal oxygen consumption and delivery of oxygen to cerebral tissues, reductions in muscular tension, structural changes in the brain • psychological—distraction from daily hassles and routine, enhanced feeling of control, feeling of competency, positive social interactions, improved self-concept and self-esteem.
C.7.4	Explain the role of exercise in reducing the effects of anxiety and depression.	3	Limit to: <ul style="list-style-type: none"> • anxiety reduction—acute effects of exercise on state anxiety, compounding effect of intensity and duration of exercise, chronic effects of

			<p>exercise on trait anxiety</p> <ul style="list-style-type: none"> depression reduction—note this is a clinical condition treated by medication. Exercise has been seen to play a significant role in alleviating depression although it is a correlational relationship; no causal link has been established. Include the nature of the exercise programme (enjoyable, aerobic or rhythmic, absence of interpersonal competition, closed and predictable environment, moderate intensity, 20–30 minutes, several times a week).
C.7.5	Discuss potential personal and environmental barriers to physical activity.	3	<p>Discussion should be based on exercise adherence, limited to:</p> <ul style="list-style-type: none"> personal factors—(i) demographic variables (ii) cognitive variables (iii) past behaviours environmental factors—(i) social environment (ii) physical environment (iii) time (iv) characteristics of physical activity offered (v) leader qualities (vi) social and cultural norms within various ethnic groups.
C.7.6	Describe strategies for enhancing adherence to exercise.	2	<p>Limit to:</p> <ul style="list-style-type: none"> environmental approaches—prompts, contracting, perceived choice reinforcement approaches—rewards for attendance and participation, external feedback, self-monitoring goal setting and cognitive approaches—associative versus dissociative focus during exercise social support approaches—role of significant others (spouse, family members, friends). Include joining in, adjusting routines, transportation, providing equipment.
C.7.7	Outline the possible negative aspects of exercise adherence.	2	<p>Limit to:</p> <ul style="list-style-type: none"> negative addiction to exercise—life choices and relationship issues symptoms of negative exercise—stereotyped pattern with a regular schedule of once or more daily, increased priority of exercise, negative mood affect with withdrawal, increased tolerance to exercise, subjective awareness of compulsion to exercise.

Option D: Nutrition for sport, exercise and health

D.1 Digestion and absorption

3 hours

	Assessment statement	Obj	Teacher's notes
D.1.1	Outline the features of the principal components of the digestive system.	2	Limit to: <ul style="list-style-type: none"> • mouth—mechanical digestion and chemical digestion • esophagus—peristalsis action • stomach—rugae, lumen, mucous coating • small intestine—villi and microvilli increase area for absorption • large intestine—water balance, vitamin absorption • pancreas—production of enzymes • liver—production of bile • gall bladder—storage of bile.
D.1.2	State the typical pH values found throughout the digestive system.	1	Mouth- 5.5 to 7.5 Stomach- 1.0 to less than 4.0_ Small intestine- 6.0 to 8.0
D.1.3	Describe the function of enzymes in the context of macronutrient digestion.	2	Limit to their role as a catalyst, that they are proteins themselves (thus activity is highest under optimum conditions of temperature and pH), and that each reaction requires a specific enzyme.
D.1.4	Explain the need for enzymes in digestion.	3	Refer to the need for increasing the rate of digestion at body temperature.
D.1.5	List the enzymes that are responsible for the digestion of carbohydrates, fats and proteins from the mouth to the small intestine.	2	Carbohydrates: salivary amylase, pancreatic amylase Fats: pancreatic lipase, bile Proteins: pepsin, trypsin
D.1.6	Describe the absorption of glucose, amino acids and fatty acids from the intestinal lumen to the capillary network.	2	Glucose, fatty acids and amino acids cross the brush-border membrane, pass through the cytosol of the absorptive cell and cross the basolateral membrane before entering the capillary network (glucose and amino acids) or the lymphatic system (fats). Consideration of more complex processes such as the re-esterification of fatty acids, consideration of fatty acid binding proteins,

apolipoproteins and chylomicrons is not required. Consideration of specific amino acid transporters, glucose transporters and the sodium–glucose co-transporter are also not required at this level.

D.2 Water and electrolyte balance

4 hours

	Assessment statement	Obj	Teacher's notes
D.2.1	State the reasons why humans cannot live without water for a prolonged period of time.	1	Water: <ul style="list-style-type: none"> is the basic substance for all metabolic processes in the body regulates body temperature enables transport of substances essential for growth allows for the exchange of nutrients and metabolic end products.
D.2.2	State where extracellular fluid can be located throughout the body.	1	Extracellular fluid includes the blood plasma and lymph, saliva, fluid in the eyes, fluid secreted by glands and the digestive tract, fluid surrounding the nerves and spinal cord and fluid secreted from the skin and kidneys.
D.2.3	Compare water distribution in trained and untrained individuals.	3	
D.2.4	Explain that homeostasis involves monitoring levels of variables and correcting changes in levels by negative feedback mechanisms.	3	
D.2.5	Explain the roles of the loop of Henlé, medulla, collecting duct and ADH in maintaining the water balance of the blood.	3	When body fluid levels are low receptors in the hypothalamus are stimulated. The hypothalamus stimulates the pituitary gland to release ADH. ADH acts on kidneys, increasing water permeability of the renal tubules and collecting ducts, leading to increased re-absorption of water.
D.2.6	Describe how the hydration status of athletes can be monitored.	2	Consider how athletes monitor urine colour, urine osmolarity and variation in body mass loss.
D.2.7	Explain why endurance athletes require a greater water intake.	3	TOK: While increased water intake is a widely recognized and accepted method of minimizing dehydration during endurance events, recently reports in the literature of hyponatremia have alerted people to the harmful, life-threatening consequences of

consuming too much low osmolality fluid. Some scientists have questioned the scientific process behind current recommendations for fluid replacement, by suggesting that much of the research has been funded by the sports drink industry, which has a vested interest.

- D.2.9 Discuss the regulation of electrolyte balance during acute and chronic exercise. 3

D.3 Energy balance and body composition

2 hours

	Assessment statement	Obj	Teacher's notes
D.3.1	Define the term <i>basal metabolic rate</i> (BMR).	1	
D.3.2	State the components of daily energy expenditure.	1	Limit to: <ul style="list-style-type: none"> basal metabolic rate thermic effect of physical activity thermic effect of feeding.
D.3.3	Explain the relationship between energy expenditure and intake.	3	
D.3.4	Discuss the association between body composition and athletic performance.	3	Consider body composition from two components, fat and fat-free mass. A distinction between fat-free mass and lean body mass should be made. The discussion should include reference to typical levels of body fat and consider the accuracy of body fat measurements (see 6.1.7).
D.3.5	Discuss dietary practices employed by athletes to manipulate body composition.	3	Include dietary practices used to decrease body fat, for example, a recommended dietary approach and more controversial methods such as diet pills, fad diets and crash diets. Also include the significance of a high protein diet for athletes aiming to increase muscle mass.

D4 Nutritional strategies

6 hours

	Assessment statement	Obj	Teacher's notes
D.4.1	State the approximate glycogen content of specific skeletal muscle fibre types.	2	Limit fibre types to: <p>slow twitch (type I)- low glycogen content</p> <p>fast twitch (type IIa)- medium glycogen content</p> <p>fast twitch (type IIb)- high glycogen content.</p>

D.4.2	Describe, with reference to exercise intensity, 2 typical athletic activities requiring high rates of muscle glycogen utilization.	Cross reference 3.3.11
D.4.3	Discuss the pattern of muscle glycogen use 3 in skeletal muscle fibre types during exercise of various intensities.	Cross reference 4.1.4.
D.4.4	Define the term <i>glycemic index</i> (GI). 1	Glycemic index is the ranking system for carbohydrates based on their immediate effect the food on blood glucose concentrations, when compared with a reference food such as pure glucose.
D.4.5	List food with low and high glycemic indexes. 1	High e.g. Glucose =100, Medium e.g. Brown rice = 50 Low e.g. Green vegetables less than 15
D.4.6	Explain the relevance of GI with regard to 3 carbohydrate consumption by athletes pre- and post-competition.	The use of high GI foods post-exercise may assist the body in restoring its glycogen stores more rapidly, aiding re-fuelling prior to future training/competition bouts. There is some evidence that lower GI foods may be beneficial prior to exercise and that our general diet. In terms of good health, should be based on carbohydrate foods with a low to medium GI.
D.4.7	Discuss the interaction of carbohydrate 3 loading and training programme modification prior to competition.	Include nutritional strategies as well as training strategies, such as tapering prior to an event.
D.4.8	State the reasons for adding sodium and 1 carbohydrate to water for the endurance athlete.	
D.4.9	Discuss the use of nutritional ergogenic aids 3 in sport.	Limit to: <ul style="list-style-type: none"> • sports drinks, bars and gels • caffeine • creatine • bicarbonate. Include ethical, health and performance enhancement considerations.
D.4.10	State the daily recommended intake of 1 protein for adult male and female non- athletes.	The WHO recommends a minimum of 0.8 g kg ⁻¹ body weight.
D.4.11	List sources of protein for vegetarian and 1 non-vegetarian athletes.	
D.4.12	Discuss the significance of strength and 3 endurance training on the recommended protein intake for male and female athletes.	
D.4.13	Outline the possible harmful effects of 2 excessive protein intake.	

Assessment outline

External assessment 76%

Paper 1 45 minutes 20%

30 multiple-choice questions on the core syllabus.

Paper 2 1 hour 15 minutes 32%

Section A: one data-based question and several short-answer questions on the core (all compulsory)

Section B: one extended-response question on the core (from a choice of three)

Paper 3 1 hour 24%

Several short-answer questions in each of the two options studied (all compulsory).

Internal assessment 24%

Group 4 project and practical work.

External assessment

The external assessment for sports, exercise and health science consists of three written papers.

Paper 1

Paper 1 is made up of multiple-choice questions that test knowledge of the core only. The questions are designed to be short, one- or two-stage problems that address objectives 1 and 2 (see the “Objectives” section). No marks are deducted for incorrect responses. Calculators are not permitted, but students are expected to carry out simple calculations.

Paper 2

Paper 2 tests knowledge of the core only. The questions address objectives 1, 2 and 3 and the paper is divided into two sections.

In section A, there is a data-based question that requires students to analyse a given set of data. The remainder of section A is made up of short-answer questions.

In section B, students are required to answer one question from a choice of three. These extended-response questions may involve writing a number of paragraphs, solving a substantial problem, or carrying out a substantial piece of analysis or evaluation. A calculator is required for this paper.

Paper 3

Paper 3 tests knowledge of the options and addresses objectives 1, 2 and 3. Students are required to answer several short-answer questions in each of the two options studied. A calculator is required for this paper.

Note: Wherever possible, teachers should use, and encourage students to use, the *Système International d'Unités* (International System of Units—SI units).

In addition to addressing objectives 1, 2 and 3, the internal assessment scheme addresses objective 4 (personal skills) using the personal skills criterion to assess the group 4 project, and objective 5 (manipulative skills) using the manipulative skills criterion to assess practical work. Calculators are not permitted in paper 1 but are required in papers 2 and 3.

Practical work and internal assessment

General introduction

The internal assessment (IA) requirements are the same for all group 4 subjects, with the exception of design technology, which has an additional element. The IA, worth 24% of the final assessment (or 36% for design technology) consists of an interdisciplinary project, a mixture of short- and long-term investigations (such as practicals and subject-specific projects) and, for design technology only, the design project.

Student work is internally assessed by the teacher and externally moderated by the IBO. The performance in IA is marked against assessment criteria, with each criterion having a maximum mark of 6.

Rationale for practical work

Although the requirements for IA are mainly centred on the assessment of practical skills, the different types of experimental work that a student may engage in serve other purposes, including:

- illustrating, teaching and reinforcing theoretical concepts
- developing an appreciation of the essential hands-on nature of scientific work
- developing an appreciation of the benefits and limitations of scientific methodology.

Therefore, there may be good justification for teachers to conduct further experimental work beyond that required for the IA scheme.

Practical scheme of work

The practical scheme of work (PSOW) is the practical course planned by the teacher and acts as a summary of all the investigative activities carried out by a student.

Syllabus coverage

The range of investigations carried out should reflect the breadth and depth of the subject syllabus at each level, but it is not necessary to carry out an investigation for every syllabus topic. However, all students must participate in the group 4 project and the IA activities should ideally include a spread of content material from the core and options. A minimum number of investigations to be carried out is not specified.

Choosing investigations

Teachers are free to formulate their own practical schemes of work by choosing investigations according to the requirements outlined. Their choices should be based on:

- subjects, levels and options taught
- the needs of their students
- available resources
- teaching styles.

Each scheme must include some complex investigations that make greater conceptual demands on students. A scheme made up entirely of simple experiments, such as ticking boxes or exercises involving filling in tables, will not provide an adequate range of experience for students.

Teachers are encouraged to use the online curriculum centre (OCC) to share ideas about possible investigations by joining in the discussion forums and adding resources in the subject home pages.

Note: Any investigation or part investigation that is to be used to assess students should be specifically designed to match the relevant assessment criteria.

Flexibility

The IA model is flexible enough to allow a wide variety of investigations to be carried out. These could include:

- short laboratory practicals over one or two lessons and long-term practicals or projects extending over several weeks
- computer simulations
- data-gathering exercises such as questionnaires, user trials and surveys
- data-analysis exercises
- general laboratory work and fieldwork.

The group 4 project

The group 4 project is an interdisciplinary activity in which all Diploma Programme science students must participate. The intention is that students from the different group 4 subjects analyse a common topic or problem. The exercise should be a collaborative experience where the emphasis is on the **processes** involved in scientific investigation rather than the **products** of such investigation.

In most cases all students in a school would be involved in the investigation of the same topic. Where there are large numbers of students, it is possible to divide them into several smaller groups containing representatives from each of the science subjects. Each group may investigate the same topic or different topics—that is, there may be several group 4 projects in the same school.

Practical work documentation

Details of an individual student's practical scheme of work are recorded on **form 4/PSOW** provided in section 4 of the *Vade Mecum*. Electronic versions may be used as long as they include all necessary information. In addition, the laboratory work corresponding to the best two marks achieved by each student when assessed using the internal assessment criteria (design, data collection and processing, and conclusion and evaluation) and the instructions given by the teacher for the laboratory work must be retained for possible inclusion in the sample work sent to an internal assessment moderator.

Time allocation for practical work

The recommended teaching times for all Diploma Programme courses are 150 hours at SL. Students of sports, exercise and health science are required to spend 40 hours on practical activities (excluding time spent writing up work). These times include 10 hours for the group 4 project. Only 2–3 hours of investigative work can be carried out after the deadline for submitting work to the moderator and still be counted in the total number of hours for the practical scheme of work.

Only some of the 40 hours of practical work need be allocated to the practical work that is assessed using the IA criteria. This will normally be done during the latter part of the course when students have become more familiar with the criteria and can be assessed in complex practical work.

Guidance and authenticity

All students should be familiar with the requirements for IA. It should be made clear to them that they are entirely responsible for their own work. It is helpful if teachers encourage students to develop a sense of responsibility for their own learning so that they accept a degree of ownership and take pride in their own work.

In responding to specific questions from students concerning investigations, teachers should (where appropriate) guide students into more productive routes of inquiry rather than respond with a direct answer. As part of the learning process, teachers can give general advice to students on a first draft of their work for IA. However, constant drafting and redrafting is not allowed and the next version handed to the teacher after the first draft must be the final one. This is marked by the teacher using the IA criteria. It is useful to annotate this work with the levels awarded for each aspect—"c" for complete, "p" for partial and "n" for not at all, to assist the moderator should the work be selected as part of the sample.

In assessing student work using the IA criteria, teachers should only mark and annotate the final draft.

When completing an investigation outside the classroom, students should work independently. Teachers are required to ensure that work submitted is the student's own. If any doubt exists, authenticity may be checked by one or more of the following methods.

- Discussion with the student
- Asking the student to explain the methods used and to summarize the results
- Asking the student to repeat the investigation

Teachers are required to sign the IA coversheet to confirm that the work of each student is his or her own unaided work.

Safety

While teachers are responsible for following national or local guidelines, which may differ from country to country, attention should be given to the mission statement below, which was developed by the International Council of Associations for Science Education (ICASE) Safety Committee.

ICASE Safety Committee

Mission statement

The mission of the ICASE Safety Committee is to promote good quality, exciting practical science, which will stimulate students and motivate their teachers, in a safe and healthy learning environment. In this way, all individuals (teachers, students, laboratory assistants, supervisors, visitors) involved in science education are entitled to work under the safest possible practicable conditions in science classrooms and laboratories. Every reasonable effort needs to be made by administrators to provide and maintain a safe and healthy learning environment and to establish and require safe methods and practices at all times. Safety rules and regulations need to be developed and enforced for the protection of those individuals carrying out their activities in science classrooms

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and laboratories, and experiences in the field. Alternative science activities are encouraged in the absence of sufficiently safe conditions.

It is a basic responsibility of everyone involved to make safety and health an ongoing commitment. Any advice given will acknowledge the need to respect the local context, the varying educational and cultural traditions, the financial constraints and the legal systems of differing countries.

Internal assessment criteria

General information

The method of assessment used for internal assessment is criterion-related. That is to say, the method of assessment judges each student in relation to identified assessment criteria and not in relation to the work of other students.

The internal assessment component in all group 4 courses is assessed according to sets of assessment criteria and achievement level descriptors. The internal assessment criteria are for the use of teachers.

- For each assessment criterion, there are a number of descriptors that each describe a specific level of achievement.
- The descriptors concentrate on positive achievement, although for the lower levels failure to achieve may be included in the description.

Using the internal assessment criteria

Teachers should judge the internal assessment exercise against the descriptors for each criterion.

The aim is to find, for each criterion, the descriptor that conveys most adequately the achievement level attained by the student. The process, therefore, is one of approximation. In the light of any one criterion, a student's work may contain features denoted by a high achievement level descriptor combined with features appropriate to a lower one. A professional judgment should be made in identifying the descriptor that approximates most closely to the work.

- Having scrutinized the work to be assessed, the descriptors for each criterion should be read, starting with level 0, until one is reached that describes an achievement level that the work being assessed does not match as well as the previous level. The work is, therefore, best described by the preceding achievement level descriptor and this level should be recorded. Only whole numbers should be used, not partial points such as fractions or decimals.
- The highest descriptors do not imply faultless performance and moderators and teachers should not hesitate to use the extremes, including zero, if they are appropriate descriptions of the work being assessed.
- Descriptors should not be considered as marks or percentages, although the descriptor levels are ultimately added together to obtain a total. It should not be assumed that there are other arithmetical relationships; for example, a level 2 performance is not necessarily twice as good as a level 1 performance.
- A student who attains a particular achievement level in relation to one criterion will not necessarily attain similar achievement levels in relation to the others. It should not be assumed that the overall assessment of the students will produce any particular distribution of scores.

- The assessment criteria should be available to students at all times.

Criteria and aspects

There are five assessment criteria that are used to assess the work of both SL and HL students.

- Design—D
- Data collection and processing—DCP
- Conclusion and evaluation—CE
- Manipulative skills—MS
- Personal skills—PS

The first three criteria—design (D), data collection and processing (DCP) and conclusion and evaluation (CE)—are each assessed twice.

Manipulative skills (MS) is assessed summatively over the whole course and the assessment should be based on a wide range of manipulative skills.

Personal skills (PS) is assessed once only and this will be during the group 4 project.

Each of the assessment criteria can be separated into three **aspects** as shown in the following sections. Descriptions are provided to indicate what is expected in order to meet the requirements of a given aspect **completely (c)** and **partially (p)**. A description is also given for circumstances in which the requirements are not satisfied, **not at all (n)**.

A “**complete**” is awarded 2 marks, a “**partial**” 1 mark and a “**not at all**” 0 marks.

The maximum mark for each criterion is 6 (representing three “completes”).

D	× 2 = 12
DCP	× 2 = 12
CE	× 2 = 12
MS	× 1 = 6
PS	× 1 = 6

This makes a total mark out of 48.

The marks for each of the criteria are added together to determine the final mark out of 48 for the IA component. This is then scaled at IBCA to give a total out of 24%.

General regulations and procedures relating to IA can be found in the *Vade Mecum* for the year in which the IA is being submitted.

Design

	Aspect 1	Aspect 2	Aspect 3
Levels/marks	Defining the problem and selecting variables	Controlling variables	Developing a method for collection of data
Complete/2	Formulates a focused problem/research question and identifies the relevant variables.	Designs a method for the effective control of the variables.	Develops a method that allows for the collection of sufficient relevant data.
Partial/1	Formulates a problem/research question that is incomplete or identifies only some relevant variables.	Designs a method that makes some attempt to control the variables.	Develops a method that allows for the collection of insufficient relevant data.
Not at all/0	Does not identify a problem/research question and does not identify any relevant variables.	Designs a method that does not control the variables.	Develops a method that does not allow for any relevant data to be collected.

Data collection and processing

	Aspect 1	Aspect 2	Aspect 3
Levels/marks	Recording raw data	Processing raw data	Presenting processed data
Complete/2	Records appropriate quantitative and associated qualitative raw data, including units and uncertainties where relevant.	Processes the quantitative raw data correctly.	Presents processed data appropriately and, where relevant, includes errors and uncertainties.
Partial/1	Records appropriate quantitative and associated qualitative raw data, but with some mistakes or omissions.	Processes quantitative raw data, but with some mistakes and/or omissions.	Presents processed data appropriately, but with some mistakes and/or omissions.
Not at all/0	Does not record any appropriate quantitative raw data or raw data is incomprehensible.	No processing of quantitative raw data is carried out or major mistakes are made in processing.	Presents processed data inappropriately or incomprehensibly.

Conclusion and evaluation

	Aspect 1	Aspect 2	Aspect 3
Levels/marks	Concluding	Evaluating procedure(s)	Improving the investigation
Complete/2	States a conclusion, with justification, based on a reasonable interpretation of the data.	Evaluates weaknesses and limitations.	Suggests realistic improvements in respect of identified weaknesses and limitations.
Partial/1	States a conclusion based on a reasonable interpretation of the data.	Identifies some weaknesses and limitations, but the evaluation is weak or missing.	Suggests only superficial improvements.
Not at all/0	States no conclusion or the conclusion is based on an unreasonable interpretation of the data.	Identifies irrelevant weaknesses and limitations.	Suggests unrealistic improvements.

Manipulative skills (assessed summatively)

This criterion addresses objective 5.

	Aspect 1	Aspect 2	Aspect 3
Levels/marks	Following instructions*	Carrying out techniques	Working safely
Complete/2	Follows instructions accurately, adapting to new circumstances (seeking assistance when required).	Competent and methodical in the use of a range of techniques and equipment.	Pays attention to safety issues.
Partial/1	Follows instructions but requires assistance.	Usually competent and methodical in the use of a range of techniques and equipment.	Usually pays attention to safety issues.
Not at all/0	Rarely follows instructions or requires constant supervision.	Rarely competent and methodical in the use of a range of techniques and equipment.	Rarely pays attention to safety issues.

*Instructions may be in a variety of forms: oral, written worksheets, diagrams, photographs, videos, flow charts, audio tapes, models, computer programs, and so on, and need not originate from the teacher.

See "The group 4 project" section for the personal skills criterion.

Clarifications of the IA criteria

Design

Aspect 1: defining the problem and selecting variables

It is essential that teachers give an open-ended problem to investigate, where there are several independent variables, from which a student could choose one that provides a suitable basis for the investigation. This should ensure that a range of plans will be formulated by students and that there is sufficient scope to identify both independent and controlled variables.

Although the general aim of the investigation may be given by the teacher, students must identify a focused problem or specific research question. Commonly, students will do this by modifying the general aim provided and indicating the variable(s) chosen for investigation.

The teacher may suggest the general research question only. Asking students to investigate some property of the musculoskeletal system, where no variables are given, would be an acceptable teacher prompt. This could be focused by the student as follows: "Does the range of movement of the hip joint change following a warm-up routine?"

Alternatively, the teacher may suggest the general research question and specify the dependent variable. An example of such a teacher prompt would be to ask the student to investigate the effect of a factor that may influence blood pressure. This could then be focused by the student as follows: "Does exercise intensity affect blood pressure?" It is not sufficient for the student merely to restate the research question provided by the teacher.

Variables are things that can be measured and/or controlled. Independent variables are those that are manipulated, and the result of this manipulation leads to the measurement of the dependent variable. A controlled variable is one that should be held constant so as not to obscure the effects of the independent variable on the dependent variable. Confounding variables are factors that may also influence the results of an experiment. Sometimes these can be measured but by definition they are not controlled and in some cases have not been identified.

The variables need to be explicitly identified by the student as the dependent (measured), independent (manipulated) and controlled variables (constants). Students should also attempt to recognize whether confounding variables are influencing their results. Relevant variables are those that can reasonably be expected to affect the outcome. For example, in the investigation "Does exercise intensity affect blood pressure?", the student must state clearly that the independent variable is the exercise intensity and the dependent variable is blood pressure. Relevant controlled variables would include ambient temperature, the age of the subject, the type of exercise. A confounding variable would be a difference in hydration status.

Students should **not** be:

- given a focused research question
- told the outcome of the investigation
- told which independent variable to select
- told which variables to hold constant.

Aspect 2: controlling variables

"Control of variables" refers to the manipulation of the independent variable and the attempt to maintain the controlled variables at a constant value. The method should include explicit reference to how the control of variables is achieved. If the control of variables is not practically possible, some effort should be made to monitor the variable(s).

A standard measurement technique may be used as part of a wider investigation but it should not be the focus of that investigation. Students should be assessed on their individual design of the wider investigation. If a standard measurement technique is used, it should be referenced using a recognised citation style. For example, while planning an investigation to study the effect of habitual dietary intake on body composition the student may select a method to measure body composition. This method may be found by referring to a primary source, a textbook, a web site or teachers notes. As is normal in science, all sources of information that are cited should be correctly referenced.

Students should **not** be told:

- which apparatus to select
- the experimental method.

Aspect 3: developing a method for collection of data

The definition of “sufficient relevant data” depends on the context. The planned investigation should anticipate the collection of sufficient data so that the aim or research question can be suitably addressed and an evaluation of the reliability of the data can be made.

If error analysis involving the calculation of standard deviation is to be carried out, then a sample size of at least five is needed. The data range and amount of data in that range are also important. For example, when implementing the Wingate test to determine peak power output, participants may be asked to complete the test on more than one occasion in order that an average peak power output can be determined. This average value should be closer to the subjects' true peak power output.

Students should **not** be told:

- how to collect the data
- how much data to collect.

Data collection and processing

Ideally, students should work on their own when collecting data.

When data collection is carried out in groups, the actual recording and processing of data should be independently undertaken if this criterion is to be assessed. Recording class or group data is only appropriate if the data-sharing method does not suggest a presentation format for the students.

Pooling data from a class is permitted where the students have independently organized and presented their data. For example, they may have placed it on a real or virtual bulletin board. (N.B. All data shared in this way must be anonymous.) For assessment of aspect 1, students must clearly indicate which data is their own.

Aspect 1: recording raw data

Raw data is the actual data measured. This may include associated qualitative data. It is permissible to convert handwritten raw data into word-processed form. The term “quantitative data” refers to numerical measurements of the variables associated with the investigation. Associated qualitative data are considered to be those observations that would enhance the interpretation of results.

Uncertainties are associated with all raw data and an attempt should always be made to quantify uncertainties. For example, when students say there is uncertainty in the measurement of height / resting heart rate, they must estimate the magnitude of the uncertainty. This can be achieved by examining the within-subject variation in the variable being measured using a test-retest procedure. Within tables of quantitative data, columns should be clearly annotated with a heading, units and an indication of the uncertainty of measurement. The uncertainty need not be the same as the manufacturer's stated precision

of the measuring device used. Significant digits in the data and the uncertainty in the data must be consistent. This applies to all measuring devices, for example, digital meters, stopwatches, and so on. The number of significant digits should reflect the precision of the measurement.

There should be no variation in the precision of raw data. For example, the same number of decimal places should be used. For data derived from processing raw data (for example, means), the level of precision should be consistent with that of the raw data.

The recording of the level of precision would be expected from the point where the student takes over the manipulation. For example, students would not be expected to state the level of precision in a solution prepared for them.

Students should **not** be told how to record the raw data. For example, they should not be given a pre-formatted table with columns, headings, units or uncertainties.

Aspect 2: processing raw data

Data processing involves, for example, combining and manipulating raw data to determine the value of a physical quantity (such as adding, subtracting, squaring, dividing), and taking the average of several measurements and transforming data into a form suitable for graphical representation. It might be that the data is already in a form suitable for graphical presentation, for example, from the Wingate test power against time or revolutions per minute against time can be plotted. If the raw data is represented in this way and a graph is drawn the raw data has been processed. Plotting raw data (without a graph line) does not constitute processing data.

The recording and processing of data may be shown in one table provided they are clearly distinguishable.

Students should **not** be told:

- how to process the data
- what quantities to graph/plot.

Aspect 3: presenting processed data

Students are expected to decide upon a suitable presentation format themselves (for example, spreadsheet, table, graph, chart, flow diagram, and so on). There should be clear, unambiguous headings for calculations, tables or graphs. Graphs need to have appropriate scales, labelled axes with units, and accurately plotted data points with a suitable best-fit line or curve (not a scatter graph with data-point to data-point connecting lines). Students should present the data so that all the stages to the final result can be followed. Inclusion of metric/SI units is expected for final derived quantities, which should be expressed to the correct number of significant figures. The uncertainties associated with the raw data must be taken into account. The treatment of uncertainties in graphical analysis requires the construction of appropriate best-fit lines.

The complete fulfillment of aspect 3 does **not** require students to draw lines of minimum and maximum fit to the data points, to include error bars or to combine errors through root mean squared calculations. Although error bars on data points (for example, standard error) are not expected, they are a perfectly acceptable way of expressing the degree of uncertainty in the data.

In order to fulfill aspect 3 completely, students should include a treatment of uncertainties and errors with their processed data, where relevant.

The treatment of error (variation) and uncertainties should be in accordance with assessment statements 6.1.1 to 6.1.4 of this guide.

Conclusion and evaluation

Aspect 1: concluding

Analysis may include comparisons of different graphs or descriptions of trends shown in graphs. The explanation should contain observations, trends or patterns revealed by the data.

When measuring an already known and accepted value of a physical quantity, students should draw a conclusion as to their confidence in their result by comparing the experimental value with the textbook or literature value. The literature consulted should be fully referenced.

Aspect 2: evaluating procedure(s)

The design and method of the investigation must be commented upon as well as the quality of the data. The student must not only list the weaknesses but must also appreciate how significant the weaknesses are. Comments about the precision and accuracy of the measurements are relevant here. When evaluating the procedure used, the student should specifically look at the processes, use of equipment and management of time.

Aspect 3: improving the investigation

Suggestions for improvements should be based on the weaknesses and limitations identified in aspect 2. Modifications to the experimental techniques and the data range can be addressed here. The modifications proposed should be realistic and clearly specified. It is not sufficient to state generally that more precise equipment should be used.

Manipulative skills

(This criterion must be assessed summatively.)

Aspect 1: following instructions

Indications of manipulative ability are the amount of assistance required in assembling equipment, the orderliness of carrying out the procedure(s) and the ability to follow the instructions accurately. The adherence to safe working practices should be apparent in all aspects of practical activities.

A wide range of complex tasks should be included in the scheme of work.

Aspect 2: carrying out techniques

It is expected that students will be exposed to a variety of different investigations during the course that enables them to experience a variety of experimental situations.

Aspect 3: working safely

The student's approach to safety during investigations in the laboratory or in the field must be assessed. Nevertheless, the teacher must not put students in situations of unacceptable risk.

The teacher should judge what is acceptable and legal under local regulations and with the facilities available. See the "Safety" section in this guide.

Personal skills

Note: The personal skills criterion is assessed in the group 4 project only and is to be found in "The group 4 project" section.

The use of information and communication technology (ICT)

In accordance with aim 7—that is, to “develop and apply the students’ information and communication technology skills in the study of science”—the use of information and communication technology (ICT) is encouraged in practical work throughout the course, whether the investigations are assessed using the IA criteria or otherwise.

Section A: use of ICT in assessment

Data-logging software may be used in experiments/investigations assessed using the IA criteria provided that the following principle is applied.

The student’s contribution to the experiment must be evident so that this alone can be assessed by the teacher. This student’s contribution can be in the selection of settings used by the data-logging and graphing equipment, or can be demonstrated in subsequent stages of the experiment.

(When data logging is used, raw data is defined as any data produced by software and extracted by the student from tables or graphs to be subsequently processed by the student.)

The following categories of experiments exemplify the application of this principle.

I. Data logging within a narrowly focused task

Data-logging software may be used to perform a traditional experiment in a new way.

Use of data-logging software is appropriate with respect to assessment if the student decides on and inputs most of the relevant software settings. For example, an investigation could be set up to monitor a person’s ventilatory response while on an cycle ergometer using a spirometer sensor linked to a calculator-based data logger in which the student controls the level of exercise (speed or workload). Data-logging software that automatically determines the various settings and generates the data tables and graphs would be inappropriate with regard to assessment because the remaining student input required to investigate the breathing capacities would be minimal.

If the experiment is suitable for assessment the following guidelines must be followed for the DCP criterion.

Data collection and processing: aspect 1

Students may present raw data collected using data logging as long as they are responsible for the majority of software settings. The numerical raw data may be presented as a table, or, where a large amount of data has been generated, by graphical means. For example, the student should set the duration and rate of the sampling, and the generated data in the form of lists of measurements from the calculator or computer could be downloaded by the student into a computer spreadsheet. Students must organize the data correctly, for example, by means of table or graph titles, columns or graph axes labelled with units, indications of uncertainties, associated qualitative observations, and so on.

The number of decimal places used in recorded data should not exceed that expressed by the sensitivity of the instrument used. In the case of electronic probes used in data logging, students will be expected to record the sensitivity of the instrument.

Data collection and processing: aspects 2 and 3

Use of software for graph drawing is appropriate as long as the student is responsible for most of the decisions, such as:

- what to graph
- selection of quantities for axes

- appropriate units
- graph title
- appropriate scale
- how to graph, for example, linear graph line and not scatter.

Note: A computer-calculated gradient is acceptable.

In the example of the investigation to monitor ventilatory response, the student could process data by drawing a graph in the spreadsheet and measuring the breathing frequency from the data. By inspecting the graph or spreadsheet data, the maximal and minimal lung volume values could be identified and used to calculate the mean tidal volume at rest. The mean volume of air breathed per minute and recovery rate after exercise could also be calculated.

Statistical analysis carried out using calculators or calculations using spreadsheets are acceptable provided that the student selects the data to be processed and chooses the method of processing. In both cases, the student must show one example in the written text. For example, the student must quote the formula used by or entered into a calculator and define the terms used, or the student must write the formula used in a spreadsheet if it is not a standard part of the program's menu of functions (for example, mean, standard deviation).

2. Data logging in an open-ended investigation

Data-logging software can enhance data collection and transform the sort of investigations possible. In this case fully automated data-logging software is appropriate with regard to assessment if it is used to enable a broader, complex investigation to be undertaken where students can develop a range of responses involving independent decision-making.

For example, a design task could be set with the teacher prompt "Investigate a factor that affects heart rate". If a heart rate monitor with automatic pre-programmed software to monitor the number of beats per minute is used, the student could use the program to develop a broader, complex investigation, for example, comparing the heart rate responses to exercise of athletes and non-athletes.

Design: aspect 1

The student must state a focused problem/research question, for example: "After a standardised exercise test, is the rate at which heart rate returns to the pre-exercise level different for trained and untrained individuals?"

Relevant variables must also be identified, for example:

- independent variable—training history
- dependent variable—heart rate
- controlled variables—temperature, age of participants, position/posture of participants after exercise.

Design: aspect 2

The student must design a method to monitor and control the variables, for example, ensure that all participants recover in the same supine position after exercise and in the same room with controlled environmental conditions. Also that the time taken from completing the exercise, adopting the supine position and the first measurement being taken is constant.

Design: aspect 3

The student must design the method for the appropriate collection of sufficient raw data. The student would choose the participants from their athletic history and/or prowess and determine the number taking part in

the experiment. The student would also decide the intensity and duration of exercise, the recovery position of the participant, the length of time the heart rate is recorded and the frequency of taking measurements.

Data collection and processing: aspect 1

Appropriate raw quantitative data would consist of the heart rate readings and the time elapsed after finishing exercise. The data could be annotated on a series of graphs or presented in a table with an appropriate title, column headings and units. Qualitative data also should be recorded, for example, the characteristics of the participant (age, gender, athletic history), resting position/posture. In addition the heart rate of the participant before taking exercise and the temperature of the room should be recorded. Calculation of uncertainties would not be expected in this experiment.

Data collection and processing: aspect 2

Graphs of heart rate against time would not be assessed, as these would have been generated automatically by the pre-programmed software on the data logger, without input from the student. However, the rates of change of heart rate derived from these graphs could be plotted against time for each participant using graph-plotting software where student input is possible, for example, choice of type of graph, x and y axes, range and scale. Alternatively data on the time taken to return to a normal heart rate could be recorded in a table or by graphical means such as a bar chart.

Data collection and processing: aspect 3

The student would generate graphs of heart rate *versus* time for each participant, which should have clear titles, correctly labelled axes, a legend for the data of the different participants, and trend lines to reveal the degree of uncertainty. The student could also produce a table combining information on the characteristics of the participants with data on recovery rates or present the same data with a bar chart.

Section B: use of ICT in non-assessed practical work

It is not necessary to use ICT in assessed investigations but, in order to carry out aim 7 in practice, students will be required to use each of the following software applications at least once during the course.

- Data logging in an experiment
- Software for graph plotting
- A spreadsheet for data processing
- A database
- Computer modelling/simulation

There are many examples of the above in the ICT resources for biology, chemistry and physics on the OCC.

Apart from sensors for data logging, all the other components involve software that is free and readily available on the Internet. As students only need to use data-logging software and sensors once in the course, class sets are not required.

The use of each of the above five elements of the use of ICT by students would be authenticated by means of entries in the students' practical scheme of work, form 4/PSOW. For example, if a student used a spreadsheet in an investigation, this should be recorded on form 4/PSOW. Any other applications of ICT can also be recorded on form 4/PSOW.

The group 4 project

Summary of the group 4 project

The group 4 project is a collaborative activity where students from different group 4 subjects work together on a scientific or technological topic, allowing for concepts and perceptions from across the disciplines to be shared in line with aim 10, that is, to “encourage an understanding of the relationships between scientific disciplines and the overarching nature of the scientific method”. The project can be practically or theoretically based. Collaboration between schools in different regions is encouraged.

The group 4 project allows students to appreciate the environmental, social and ethical implications of science and technology. It may also allow them to understand the limitations of scientific study, for example, the shortage of appropriate data and/or the lack of resources. The emphasis is on interdisciplinary cooperation and the processes involved in scientific investigation, rather than the products of such investigation.

The choice of scientific or technological topic is open but the project should clearly address aims 7, 8 and 10 of the group 4 subject guides.

Ideally, the project should involve students collaborating with those from other group 4 subjects at all stages. To this end, it is not necessary for the topic chosen to have clearly identifiable separate subject components. However, for logistical reasons some schools may prefer a separate subject “action” phase (see the following “Project stages” section).

Project stages

The 10 hours allocated to the group 4 project, which are part of the teaching time set aside for IA, can be divided into three stages: planning, action and evaluation.

Planning

This stage is crucial to the whole exercise and should last about two hours.

- The planning stage could consist of a single session, or two or three shorter ones.
- This stage must involve all group 4 students meeting to “brainstorm” and discuss the central topic, sharing ideas and information.
- The topic can be chosen by the students themselves or selected by the teachers.
- Where large numbers of students are involved, it may be advisable to have more than one mixed subject group.

After selecting a topic or issue, the activities to be carried out must be clearly defined before moving from the planning stage to the action and evaluation stages.

A possible strategy is that students define specific tasks for themselves, either individually or as members of groups, and investigate various aspects of the chosen topic. At this stage, if the project is to be experimentally based, apparatus should be specified so that there is no delay in carrying out the action stage. Contact with other schools, if a joint venture has been agreed, is an important consideration at this time.

Action

This stage should last around six hours and may be carried out over one or two weeks in normal scheduled class time. Alternatively, a whole day could be set aside if, for example, the project involves fieldwork.

- Students should investigate the topic in mixed subject groups or single subject groups.
- There should be collaboration during the action stage; findings of investigations should be shared with other students within the mixed/single subject group. During this stage, in any practically based activity, it is important to pay attention to safety, ethical and environmental considerations.

Note: Students studying two group 4 subjects are not required to do two separate action phases.

Evaluation

The emphasis during this stage, for which two hours is probably necessary, is on students sharing their findings, both successes and failures, with other students. How this is achieved can be decided by the teachers, the students or jointly.

- One solution is to devote a morning, afternoon or evening to a symposium where all the students, as individuals or as groups, give brief presentations.
- Alternatively, the presentation could be more informal and take the form of a science fair where students circulate around displays summarizing the activities of each group.

The symposium or science fair could also be attended by parents, members of the school board and the press. This would be especially pertinent if some issue of local importance has been researched. Some of the findings might influence the way the school interacts with its environment or local community.

Addressing aims 7 and 8

Aim 7—"develop and apply the students' information and communication technology skills in the study of science".

Aim 7 may be partly addressed at the planning stage by using electronic communication within and between schools. It may be that ICT (for example, data logging, spreadsheets, databases, and so on) will be used in the action phase and certainly in the presentation/evaluation stage (for example, use of digital images, presentation software, web sites, digital video, and so on).

Aim 8—"raise awareness of the moral, ethical, social, economic and environmental implications of using science and technology".

The choice of topic should enable one or more elements of aim 8 to be incorporated into the project.

Addressing the international dimension

There are also possibilities in the choice of topic to illustrate the international nature of the scientific endeavour and the increasing cooperation required to tackle global issues involving science and technology. An alternative way to bring an international dimension to the project is to collaborate with a school in another region.

Types of project

While addressing aims 7, 8 and 10 the project must be based on science or its applications.

The project may have a hands-on practical action phase or one involving purely theoretical aspects. It could be undertaken in a wide range of ways.

- Designing and carrying out a laboratory investigation or fieldwork.
- Carrying out a comparative study (experimental or otherwise) in collaboration with another school.
- Collating, manipulating and analysing data from other sources, such as scientific journals, environmental organizations, science and technology industries and government reports.
- Designing and using a model or simulation.
- Contributing to a long-term project organized by the school.

Logistical strategies

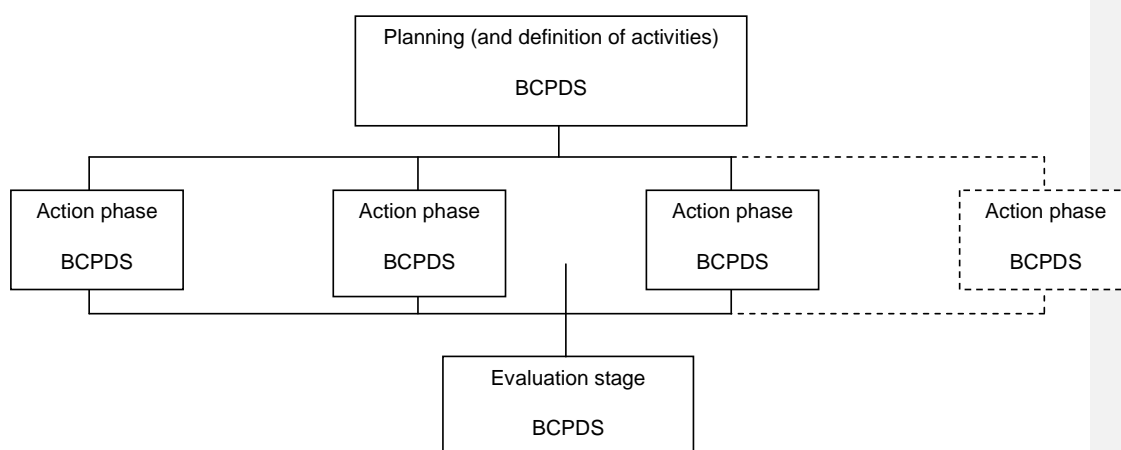
The logistical organization of the group 4 project is often a challenge to schools. The following models illustrate possible ways in which the project may be implemented.

Models A, B and C apply within a single school, and model D relates to a project involving collaboration between schools.

Model A: mixed subject groups and one topic

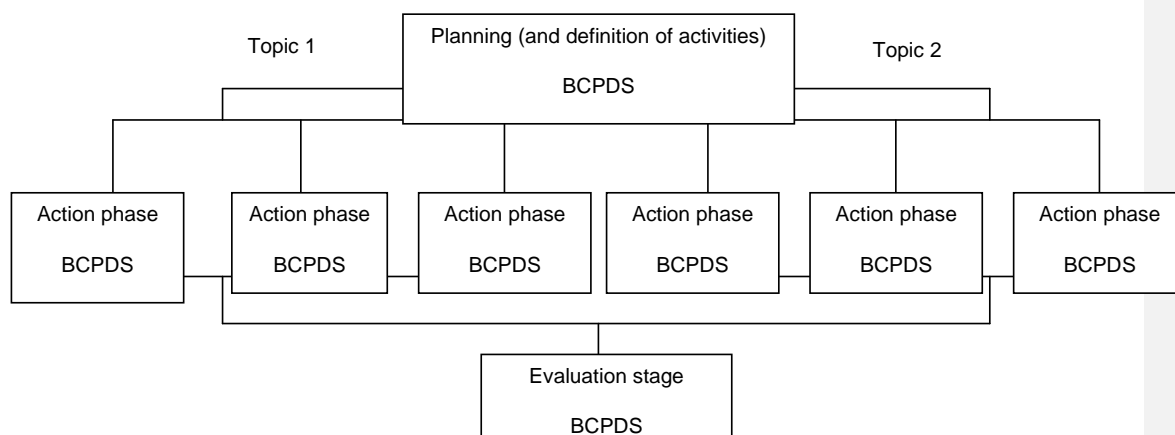
Schools may adopt mixed subject groups and choose one common topic. The number of groups will depend on the number of students. The dotted lines in the model show the addition of more groups as student numbers increase.

B—biology C—chemistry P—physics D—design technology S – sports, exercise and health science



Model B: mixed subject groups adopting more than one topic

Schools with large numbers of students may choose to do more than one topic.



Model C: single subject groups

For schools opting for single subject groups with one or more topics in the action phase, simply replace the mixed subject groups in model A or B with single subject groups.

Model D: collaboration with another school

The collaborative model is open to any school. To this end, the IBO will provide an electronic collaboration board on the OCC where schools can post their project ideas and invite collaboration from another school. This could range from merely sharing evaluations for a common topic to a full-scale collaborative venture at all stages.

For schools with few diploma students or schools with certificate students, it is possible to work with non-Diploma Programme or non-group 4 students or undertake the project once every two years. However these schools are encouraged to collaborate with another school. This strategy is also recommended for individual students who may not have participated in the project, for example through illness or because they have transferred to a new school where the project has already taken place.

Timing

The 10 hours that the IBO recommends be allocated to the project may be spread over a number of weeks. The distribution of these hours needs to be taken into account when selecting the optimum time to carry out the project. However, it is possible for a group to dedicate a period of time exclusively to project work if all/most other school work is suspended.

Year 1

In the first year, students' experience and skills may be limited and it would be inadvisable to start the project too soon in the course. However, doing the project in the final part of the first year may have the advantage of reducing pressure on students later on. This strategy provides time for solving unexpected problems.

Year 1–year 2

The planning stage could start, the topic could be decided upon, and provisional discussion in individual subjects could take place at the end of the first year. Students could then use the vacation time to think about how they are going to tackle the project and would be ready to start work early in the second year.

Year 2

Delaying the start of the project until some point in the second year, particularly if left too late, increases pressure on students in many ways: the schedule for finishing the work is much tighter than for the other options; the illness of any student or unexpected problems will present extra difficulties. Nevertheless, this choice does mean students know one another and their teachers by this time, have probably become accustomed to working in a team and will be more experienced in the relevant fields than in the first year.

Combined SL and HL

Where circumstances dictate that the project is only carried out every two years, HL beginners and more experienced SL students can be combined.

Selecting a topic

Students may choose the topic or propose possible topics, with the teacher then deciding which one is the most viable based on resources, staff availability, and so on. Alternatively, the teacher selects the topic or proposes several topics from which students make a choice.

Student selection

Students are likely to display more enthusiasm and feel a greater sense of ownership for a topic that they have chosen themselves. A possible strategy for student selection of a topic, which also includes part of the planning stage, is outlined here. At this point, subject teachers may provide advice on the viability of proposed topics.

- Identify possible topics by using a questionnaire or a survey of students.
- Conduct an initial “brainstorming” session of potential topics or issues.
- Discuss, briefly, two or three topics that seem interesting.
- Select one topic by consensus.
- Students make a list of potential investigations that could be carried out. All students then discuss issues such as possible overlap and collaborative investigations.

Assessment

The group 4 project is to be assessed for the personal skills criterion only and this will be the only place where this criterion is assessed. It is up to the school how this assessment takes place.

Note: The group 4 project is not to be used for the assessment of the other criteria.

Personal skills (for group 4 project assessment only)

This criterion addresses objective 4.

	Aspect 1	Aspect 2	Aspect 3
Levels/marks	Self-motivation and perseverance	Working within a team	Self-reflection
Complete/2	Approaches the project with self-motivation and follows it through to completion.	Collaborates and communicates in a group situation and integrates the views of others.	Shows a thorough awareness of their own strengths and weaknesses and gives thoughtful consideration to their learning experience.
Partial/1	Completes the project but sometimes lacks self-motivation.	Exchanges some views but requires guidance to collaborate with others.	Shows limited awareness of their own strengths and weaknesses and gives some consideration to their learning experience.
Not at all/0	Lacks perseverance and motivation.	Makes little or no attempt to collaborate in a group situation.	Shows no awareness of their own strengths and weaknesses and gives no consideration to their learning

			experience.
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The assessment can be assisted by the use of a student self-evaluation form, but the use of such a form is not a requirement.

Action Verbs

These action verbs indicate the depth of treatment required for a given assessment statement. These verbs will be used in examination questions and so it is important that students are familiar with the following definitions.

Objective 1

Define	give the precise meaning of a word, phrase or physical quantity
Draw	represent by means of pencil lines
Label	add labels to a diagram
List	give a sequence of names or other brief answers with no explanation
Measure	find a value for a quantity
State	give a specific name, value or other brief answer without explanation or calculation

Objective 2

Annotate	add brief notes to a diagram or graph
Apply	use an idea, equation, principle, theory or law in a new situation
Calculate	find a numerical answer showing the relevant stages in the working (unless instructed not to do so)
Describe	give a detailed account
Distinguish	give the differences between two or more different items
Estimate	find an approximate value for an unknown quantity
Identify	find an answer from a given number of possibilities
Outline	give a brief account or summary

Objective 3

Analyse	interpret data to reach conclusions
Comment	give a judgement based on a given statement or result of a calculation
Compare	give an account of similarities and differences between two (or more) items, referring to both (all)

	of them throughout
Construct	represent or develop in graphical form
Deduce	reach a conclusion from the information given
Derive	manipulate a mathematical relationship/s to give a new equation or relationship
Design	produce a plan, object, simulation or model
Determine	find the only possible answer
Discuss	give an account including, where possible, a range of arguments, for and against the relative importance of various factors, comparisons of alternative hypotheses
Evaluate	assess the implications and limitations
Explain	give a detailed account of causes, reasons or mechanisms
Predict	give an expected result
Show	give the steps in a calculation or derivation
Sketch	represent by means of a graph showing a line and labelled but unscaled axes but with important features(e.g. intercept) clearly indicated
Solve	obtain an answer using algebraic and/or numerical methods
Suggest	propose a hypothesis or other possible answer